MARK HANCOCK — RESEARCH STATEMENT

The perception that most people have of what it means to use a computer has been gradually changing over the past few decades. Recent advances in computer technology have begun to speed up this change in perception: the idea of using a mouse to point and click and a keyboard to type in text has transformed into ideas such as ubiquitous computing [6] and embodied interaction [1]. Instead of people sitting at their desk interacting with a small vertical screen, people are interacting with technology in many aspects of their day-to-day life – resulting in the use of their fingers, hands, arms, and whole bodies to trigger interaction.

Multi-finger interaction provides the ability to move and rotate 3D objects on an interactive surface.

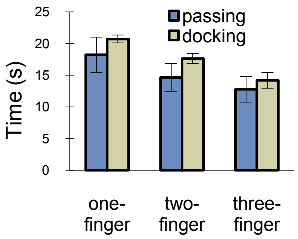
In my dissertation, I have focused on the use of multiple fingers on *interactive tabletops*. Specifically, my work has explored how to bring some of the richness of our interactions with physical artefacts to the manipulation of virtual 3D objects on a tabletop display. To move past the limitations of the traditional point-and-click interaction, I consider virtual objects as though they are tools that can be used for a variety of purposes. My research thus far has focused primarily on discovering the fundamentals required to enable this new way of interfacing with computers, but this has in turn opened up a multitude of potential research directions.

DISSERTATION RESEARCH

Context-Rooted Rotatable Draggables (CoR²Ds): an example of a 2D interaction technique I developed for tabletop displays.

On traditional tables, people frequently use the third dimension to sort, organize and store objects. In my Ph.D. thesis, I demonstrate how to incorporate 3D visuals and interaction on a digital table to enrich collaboration. Previous research in tabletop display environments was largely limited to two dimensions, perhaps due to the 2D nature of the surface itself. Research in 3D virtual environments was typically explored in vertical displays and involved complex input devices. In my research, I consider what effect 3D has on collaboration and what benefit 3D could provide to collaborative activities. In the specific domain of 3D tabletop interfaces, I have three primary contributions: I introduce *interaction techniques on the table's surface* that use multitouch to enable full control of virtual objects in 3D, I show that *multiple people can share the same 3D display* without viewpoint inconsistencies interfering with collaboration, and I integrate these visuals and interaction techniques in *virtual tools to support sandtray therapy* – a form of art therapy involving child-therapist collaboration.

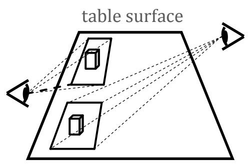
My exploration of 3D has come at a particularly advantageous time, since my research is complementary to the recent focus on designing and deploying devices with massively multi-touch capabilities. Thus, I have been able to invent interactions that use several touches to provide people with the ability to move and rotate virtual 3D objects on such a surface. New interaction techniques in these settings are affected by a variety of new design constraints, including the importance of a *visual and physical connection* between a person's touch point and the virtual objects they are controlling; how our minds currently think about *moving and rotating objects* in the physical world; an appropriate *visual feedback* that leverages our understanding of how 3D objects look in the physical world; and simultaneous touches from *multiple people* and *multiple fingers*.



People both prefer and perform better with more fingers for interaction.

INTERACTING WITH VIRTUAL 3D OBJECTS

I developed three interaction techniques using one, two, or three fingers [3] that allow the full rotation of virtual objects (three dimensions), but limit the movement to the surface of the table (two dimensions). I performed a user study to compare these three techniques, the results of which showed that people both preferred and performed better when they could use both hands and multiple fingers (the two- and three-finger techniques). Participants also pointed out that, when using three fingers to interact, it felt much more like they were "picking up" the object, indicating that this technique better approximates their understanding of the physical world.

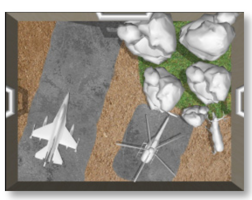


Virtual objects can be adjusted to the perspective of different viewers at a tabletop display.

VIEWING 3D OBJECTS AT AN INTERACTIVE SURFACE

I developed several methods to allow many people to simultaneously view a 3D scene projected onto a 2D surface [2], even when they stand at different sides of the table. I provide ways of partitioning the display so that objects are rendered to appear better when they are close to "your" side of the table as well as ways of providing people with control over which objects will look better at which side of the table. I also performed a user study to evaluate the need for alternate perspectives at a digital table [4].

A physical sandbox used for sandtray therapy.



A scene created using the virtual sandtray in a 3D environment on a multi-touch tabletop display.

USING VIRTUAL TOOLS FOR SANDTRAY THERAPY

I took an interdisciplinary approach to demonstrate these techniques in a more realistic setting. Using a co-operative design strategy, including both art therapists and interaction design experts, we combined the appropriate visuals with the favoured interaction technique (three-finger interaction) in a virtual 3D sandtray therapy application intended for young children. We implemented an environment that supports physical effects, such as object collisions and the ability to toss an object and have it tumble across the screen [5]. With this combination, the virtual objects can be repurposed as tools. For example, an oblong object can be used to "sweep away" other objects and clear the screen, and a concave object can be used to collect other objects. Tools can also provide a special-purpose function, such as a bucket with a dial that, when another object is placed inside, the dial can be used to grow or shrink the object. All of these actions serve as valuable hints to the therapist about the child's psyche.

RESEARCH DIRECTIONS

In my thesis work, I explore groups of people simultaneously interacting with virtual 3D objects by directly touching a large horizontal display. The absence of a mouse and keyboard, together with the ability to directly interact, allows people to begin to feel as though the objects are an extension of themselves – they become virtual tools. My future work will involve extending the notion of embodied interaction to other interaction domains, such as direct touch on wall displays, remote pointing, and tablets.

How can we leverage the freedoms of the physical world, together with the power of computing? In the *physical world*, an artefact reacts to a person's actions depending on its physical properties. For example, a book can be stacked on top of another because it has two flat sides or a pencil can be rolled along a desk because it is cylindrical. People often make use of the unique properties of objects to make them affect other objects in different ways. People use pencils to write, hammers to insert nails, and utensils to facilitate cooking. In the *virtual world*, how objects react to human intervention depends on a particular mapping of human movement to visual feedback. For example, pressing a button with a mouse cursor can cause a variety of behaviour, including opening a menu, advancing to the next page of a document, or invoking a new window to appear. There are benefits to both worlds; in the physical world, people become familiar with the capabilities of the tools they use regularly; in a virtual world the result of people's actions can be made to ignore physical limits.

An example of a project where I combine direct touch with remote pointing to paint on a virtual canvas.

In my future research, I would like to explore how to extend the basic concept of affecting a computer's behaviour with virtual tools to other devices, such as direct-touch wall displays, tangible objects and remote pointing. Applying the idea of embodied interaction may help to bridge the gap between what people do physically with their hands and bodies and what effect these actions have in the virtual world. This research direction will leverage the benefits of both the physical and the virtual.

How does this integrated physical/virtual interaction compare to existing techniques? In creating new ways of interacting that make use of the combination of the physical and the virtual, I will consider and compare existing techniques for these novel devices in light of my particular goal of supporting embodiment. The performance and usability of these new techniques will then be evaluated in a series of controlled studies to establish a foundation on which the remainder of this research can be built.

How could embodied interaction techniques be incorporated into real-world applications? In the long term, I will develop several applications that use the idea of embodiment to improve real work practices. This research will involve the iterative design of embodied technology through observation, contextual-interviews and testing with domain experts. This research will start from a specific domain, such as the visualisation of research data (e.g., in astronomy), educational exploration (e.g., in a classroom or science museum), or art creation (e.g., on a virtual canvas). Expanding to different domains will provide interesting opportunities to explore the specifics and variations of supporting task and work practices in these domains.

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