XNT: Object Transformation on Multi-Touch Surfaces

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ABSTRACT
We present and evaluate a new object transformation technique for multi-touch surfaces. Specifying complete object transformations for a two-dimensional space requires a minimum of four degrees of freedom (DOF): two for position, one for rotation, and another for scaling. Many existing techniques for object transformation are designed to function with traditional input devices such as mice, single-touch surfaces, or stylus pens. The challenge is then to compensate for the lack of DOF's. *XNT* is a new three-finger object transformation technique, designed specifically for multi-touch surface devices. It provides a natural interface for object manipulation and was experimentally found to be faster than previous techniques.

ACM Classification Keywords
H.5.3 [User Interfaces]: Interaction styles.

INTRODUCTION
Multi-touch surfaces have grown in popularity in recent years, owing partially to the effort of major technology and communication companies. The multi-user collaborative experience of Microsoft's *Surface* [2], SMART Technologies' *SMART Table* [4], Mitsubishi's *DiamondTouch* [1], and Perceptive Pixel's *Interactive Media Wall* [3] facilitates development of a more natural and intuitive form of human-computer interaction.

One of the most fundamental interactions with visual content involves changing the position, size, and orientation of the displayed objects. Collectively known as object transformation in the field of computer graphics, the act of translating, scaling, and rotating is essential for any graphical user-interface (GUI).

Digital tabletops offer face-to-face collaboration to multiple users by allowing them to gather around a table and observe the displayed content from multiple viewpoints around the table. These multiple viewpoints introduce a design challenge: visual content properly oriented and legible to one user may not be so to another user [6]. Inevitably, there is a need to investigate, develop, and evaluate techniques that allow multiple users to freely transform visual content to match their own viewpoints. Scaling is important here, too as users may need to access more or less detail at any time.

TRANSFORMATION TECHNIQUES
Various techniques have been developed to allow transformation of visual content on touch surfaces. In general, transformations are specified as three components: translation, rotation, and scale. However, only the first two are widely supported by existing techniques. A major obstacle in designing transformation techniques is the number of degrees of freedom (DOF) provided by the input device. E.g.. a mouse offers only two DOF's in a direct way. Multi-touch devices are capable of producing more DOF's for input. This invites the design of techniques that are able to encapsulate all components of transformation in a single gesture.

Lui et al. describe a set of techniques collectively known as *TNT* [6]. There the detection of touch, hand motion, and the angle of rotation are detected using a Polhemus *Fastrak* three-dimensional tracking system. In one approach, *TNT-hand*, the tracker is placed inside a "finger sleeve" and is worn on the index finger. In another approach, called *TNT-block,* the tracker is placed inside a cylindrical block, which can be held and rolled between the fingers. The results of their user study indicate that *TNT-block* and *TNT-hand* techniques outperform the *Rotate'N Translate* (*RNT*) [5] technique.

Our study involves an evaluation and comparison of *TNT* versus our new three-finger technique called *XNT*.

XNT: DESIGN AND MOTIVATIONS
Specifying a general transformation in a two-dimensional space requires at least four DOF's. Traditional input devices such as the mouse only afford 2DOF for input, preventing a one-to-one correspondence between input and output. Similarly, tracking a single touch or device on a plane also affords only 2DOF's. Due to this restriction, the best evaluated techniques in the literature, *TNT* and *RNT,* do not discuss the scaling component of transformation.

Existing 2-finger techniques offer 4 DOF's for input. However, this does not reflect any natural way of rotating an object with one hand. Using the triad of thumb, index, and middle fingers together improves stability and control and allows 6DOF input beneficial for the development of more accurate rotation and scaling functionality.

IMPLEMENTATION

The experiment was performed on the *Multi-User Laser Table Interface* (*MULTI*) platform [7], consisting of three back-projected walls and a table top display. Equipped with multiple OptiTrack *FLEX:C120* optical cameras, the interface captures and reports the movement of bright points of light, normally generated via laser pointers. To add touch-detection capabilities to *MULTI*, we constructed a touch-glove equipped with three red LEDs placed on the tip of the thumb, index, and middle fingers.

Figure 1. An overview of the apparatus: (a) MULTI system [9] consisting of 3 interactive walls and a table top, (b) Touch-glove prototype designed to add touch functionality to MULTI.

Due to the use of a highly diffuse projection surface and the brightness threshold in the camera system, the LED's are only detected only when they touch the surface. Figure 1 displays the *MULTI* and the touch-glove prototype.

A major advantage of this approach to touch detection is the possibility of accurate distinction between the fingers touching the surface. This can be achieved by blinking the LEDs in appropriate patterns. The same concept also applies to different hands and even different users: in a multi-touch multi-user environment, each user will have a different blinking pattern for each glove and finger.

TASKS

The user study consisted of two tasks: precise and imprecise targeting. The precise targeting task involved transformation of objects within the personal territory of the user to a precise position and angle. In the imprecise targeting task, the techniques are examined for use in collaborative environments in which quick transfer of objects to the other edges of the tabletop takes priority over precision of transformation. This replicates the design of an experiment in the literature [6].

DISCUSSION

A repeated-measure ANOVA performed on the data gathered during the pilot study revealed a significant main effect of technique on task completion time ($F_{1,5} = 10.27$, $p < .05$).

Overall, participants completed the precise task 21% and the imprecise task 16% quicker using *XNT* compared to *TNT* as is illustrated in Figure 3.

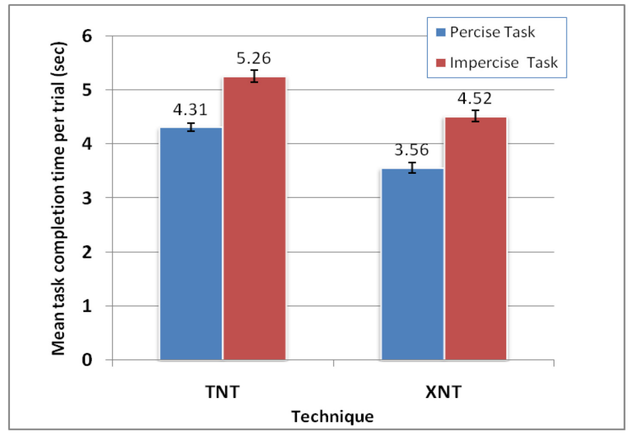

Figure 2. Mean task completion time by technique and task. Error bars show ±1 *SE*.

However, the results of the pilot study are not necessarily valid as there were some technical difficulties around camera calibration. A future study with a correct calibration will serve as a more authoritative study.

REFERENCES

1. MERL DiamondTouch. http://www.merl.com/projects/DiamondTouch/.
2. Microsoft Surface. http://www.microsoft.com/surface/
3. Perceptive Pixel Media Wall. http://www.perceptivepixel.com/about.html.
4. SMART TABLE. http://www2.smarttech.com/st/en-US/ Products/ SMART+Table/default.htm.
5. Kruger, R., Carpendale, S., Scott, S. D., and Tang, A., Fluid integration of rotation and translation, *Proceedings ACM CHI 2005*.
6. Liu, J., Pinelle, D., Sallam, S., Subramanian, S., and Gutwin, C., TNT: Improved rotation and translation on digital tables, *Proceedings of Graphics Interface 2006*.
7. Stuerzlinger, W., Zaman, L., Pavlovych, A., and Oh, J.-Y., The design and realization of CoViD: a system for collaborative virtual 3D design, *Virtual Reality*, *10*, 2006, 135-147.