Up- and Downwards Motions in 3D Pointing

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ABSTRACT
We present an experiment that examines 3D pointing in fish tank VR using the ISO 9241-9 standard. The experiment used three pointing techniques: mouse, ray, and touch using a stylus. It evaluated user pointing performance with stereoscopically displayed varying height targets above an upward-facing display. Results show differences in upwards and downwards motions for the 3D touch technique.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices, interaction styles.

Keywords
Pointing; Fitts' law; ISO 9241-9; virtual reality.

1. INTRODUCTION
We present a pointing experiment based on previous work [3], comparing the mouse (an established performance benchmark, see e.g., [2, 4]) to two pen techniques. One required touching targets, while the other used remote pointing via ray casting. We had two goals: 1) to investigate effects of target height (relative to the display) and 2) to evaluate the effect of movement direction. We previously [3] observed such effects, but did not analyze them.

2. EXPERIMENT
Twelve volunteers participated in our study. We used a fish-tank VR system with a NaturalPoint *OptiTrack* system to track the head and pen. The software displayed a 3D version of the ISO 9241-9 [1] task, (Figure 1, left). Participants selected the highlighted target using the current pointing technique.

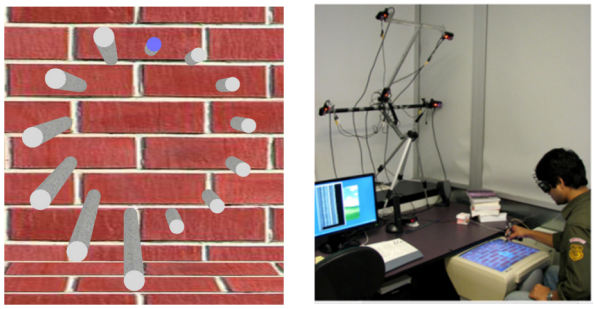

Figure 1. (Left) The pointing task. (Right) The setup.

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In every target circle, half of the targets were at one depth, and the rest were at another, using all 2 cm increments between 8 and 0 cm relative to the display surface. Every motion required depth, either moving down toward the screen, or up away from the screen. Mouse pointing used a mono screen-plane cursor. The first pen mode used ray-casting, while the second required participants directly touch targets with the tip of the pen.

3. RESULTS
There were significant main effects for both technique ($F_{2,11} = 65.8$, $p < .05$) and height difference ($F_{3,11} = 7.4$, $p < .05$) on movement time. Touch was worst overall, especially for larger height differences (i.e., 6 to 8 cm differences), while mouse was fastest. Motion direction (upward vs. downward motion) did not affect movement time. Throughput, calculated according to ISO 9241-9 [1], showed a significant interaction between movement direction and technique ($F_{2,11} = 5.5$, $p < .05$) – upwards motions with the touch condition were worse than downwards motions. The other two techniques were not affected by this. A similar effect was found for error rate. There was a significant effect between motion direction and technique ($F_{2,11} = 7.54$, $p < .05$) for error rate: Touch error rate decreased significantly from around 30% to around 23% for *downward* motions, while the other two techniques both improved significantly for *upward* motions.

4. CONCLUSIONS
Performance with downward touch motions may be higher, as participants can visually overlap the pen tip with the target, and move down until hitting the target. Moving *upwards* (away from the display) is more difficult, possibly because of conflicting occlusion and stereo cues. Mouse pointing likely performed best because it allows 2D pointing at target projections, which scale larger for closer targets. This may explain why error rates were lower for upward motions with the mouse and ray [4]; the pointing task was effectively easier due to this scaling effect.

5. REFERENCES
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