The “Silk Cursor”: Investigating Transparency for 3D Target Acquisition

ABSTRACT
This study investigates dynamic 3D target acquisition. The focus is on the relative effect of specific perceptual cues. A novel technique is introduced and we report on an experiment that evaluates its effectiveness. There are two aspects to the new technique. First, in contrast to normal practice, the tracking symbol is a volume rather than a point. Second, the surface of this volume is semi-transparent, thereby affording occlusion cues during target acquisition. The experiment shows that the volumehcclusioneffective in both monocular and stereoscopic conditions. For some tasks where stereoscopic presentation is unavailable or infeasible, the new techniaue offers an effective alternative.

Keywords : Dsemi-transparency, translucency, partial occlusion, stereopsis, depth perception, 3D interfaces.

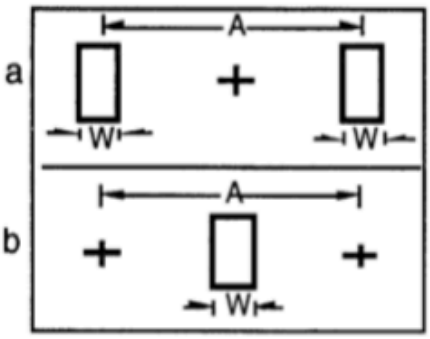

Figure 1. Two representations of Fitts' Law. The top half (a) shows the traditional representation. Targets of width "W" are selected by the cursor (the point defined by the "+"), across amplitude "A". In the lower half (b), two points (represented by the two "+" symbols), separated by amplitude "A" are selected by a cursor of width "W".

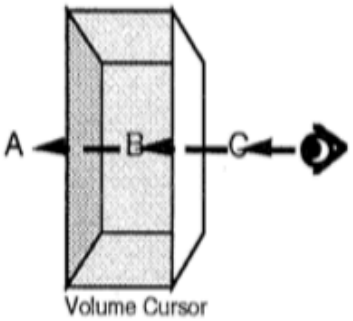

Figure 2: Using a "silk" covering over a rectangular volume cursor in order to obtain occlusion-based depth cues. An object at point A is seen through two layers of "silk", and so is perceived to be *behind* the volume cursor. An object at point B is seen through one layer, and so is perceived as *inside* the cursor's volume. An object at point C is not occluded by the silk at all, and so is seen to be *in front* of the volume.

Experimental Task

A 3D dynamic target acquisition task, “virtual fishing”, was designed for the experiment. In each trial of the experiment, an “angel fish” with random size and color appears swimming around randomly within a 3D environment, as shown in Fig. 3

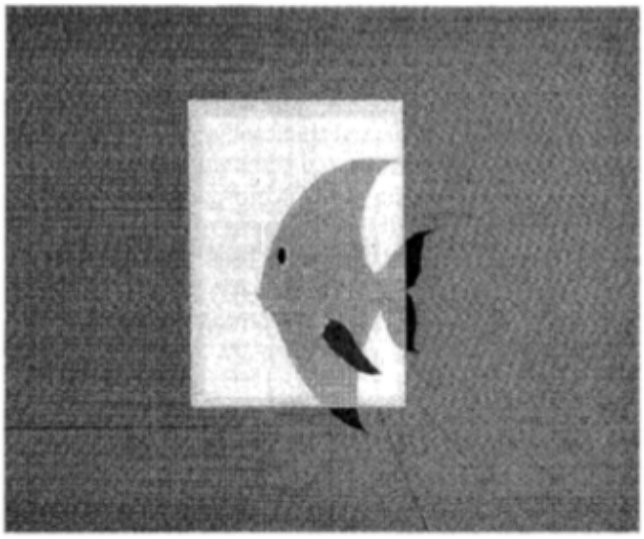

Figure 3: The "fishing" task

Eleven male and one female paid volunteers served as subjects in this experiment. The subjects were screened through the Bausch & Lomb Orthorator visual acuity and stereopsis tests. Subjects ages ranged from 18 to 36, with the majority in their early and mid-20’s. One of the 12 subjects was left handed and the rest were right handed, as determined by the Edinburgh inventory. Subjects were asked to wear the input glove on their dominant hand

A balanced within subjects design was used. The 12 subjects were randomly assigned to a unique order of the four conditions (SS, SW, MS, MW) by a hyper-Graeco- Latin square pattern, which resulted in every condition being presented an equal number of times as fiist, second, third and finat condition.

Following a 2 minute demonstration of all experimental conditions, the experiments with each subject were divided into four sessions, with one experimental condition in each session. There was a 1 minute rest between every two sessions. Each session comprised 5 tests. Test 1 started when the subject had no experience with the particulw experimental condition. Test 2, 3, 4, and 5 started after the subjects had 3, 6, 9 and 12 minutes experience respective y. Practice trials occurred between the tests. Each test had 15 trials of fish catching. At the end of each test, the number fish both caught and missed (as both an absolute number and a relative percentage) and mean trial time were displayed to the subject.

At the end of the experiment, a short questionnaire was conducted to colleci users’ subjective preferences for all experimental conditions.

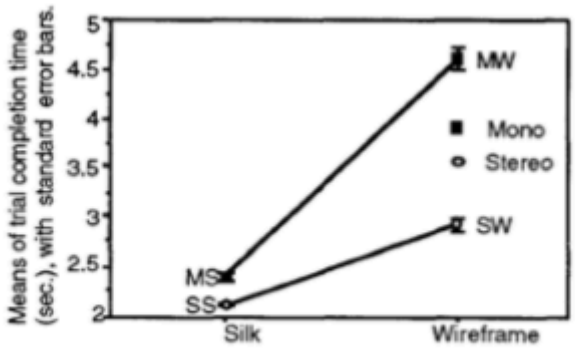

Figure 4: Trial completion time performance in relation to cursor type and display mode

Ranking these results in the order from best to worst, the mean completion time for each of the four interfaces were as follows. SS: 2.09 sec.; MS: 2.38 sec.; SW: 2.90 sec.; MW: 4.61 sec. Post hoc analysis shows that the differences between every pair of interfaces were significant, all at the $p < .0001$ level.

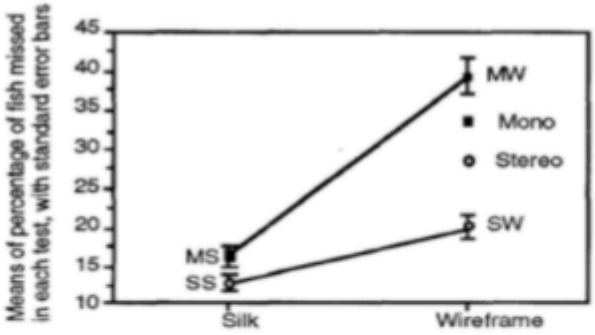

Figure 5: Error rate in relation to cursor type and display mode

Error Magnitude. The effect of cursor type and display mode on error magnitude are shown in Fig. 6. Error magnitude was significantly affected by cursor type ($F(1, 761) = 19.9$, $p<.0001$), display mode ($F(1, 761) = 39.2$, $p<.0001$), subjects ($F(11, 761) = 3.60$, $p<.0001$), and experimental phase ($F(4, 761) = 3.88$, $p = 0.004$). No significance for cursor type and display mode interaction ($F(1, 761) = .009$, $p = .92$) was found, however.

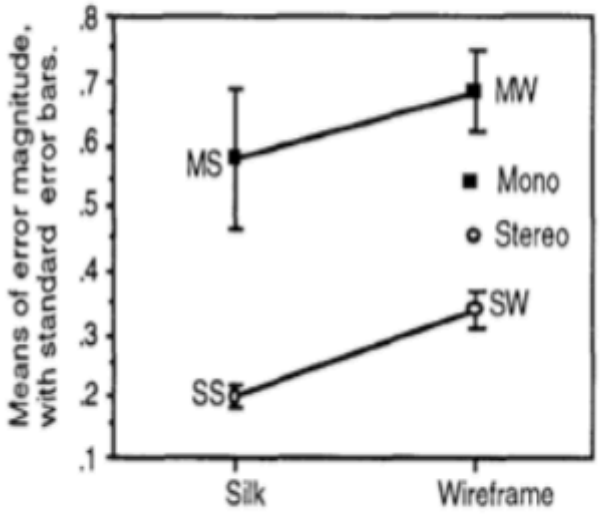

Figure 6: Error magnitude in relation to cursor type and display mode

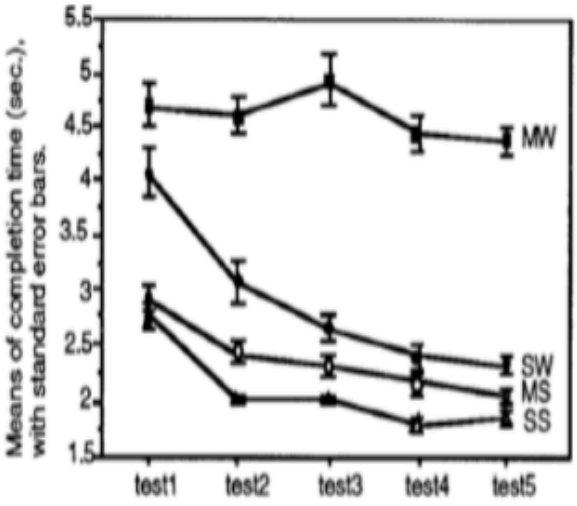

Figure 7: Time performance with four interfaces at each learning phase

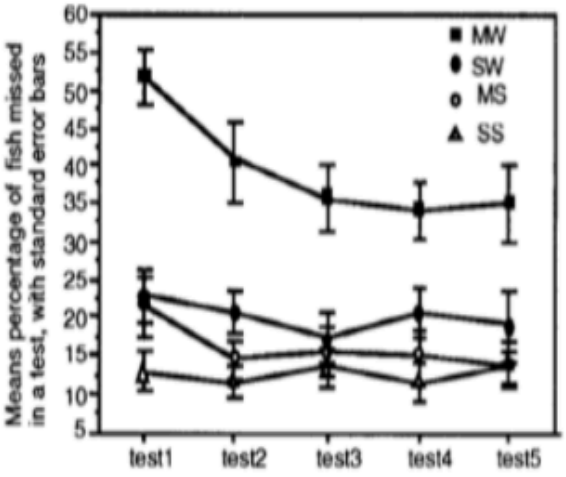

Figure 8: Error rate with four interfaces at each learning phase

Subjective Preferences

	Very Low	Low	OK	High	Very High
MW	8	3	1		
MS			4	4	4
SW		2	7	3	
SS				3	9

Table 1: Subjective preferences (each cell contains the number of subjects with that rating)

Two points of particular interest with respect to the silk cursor distinguish this research from other studies. One of these is the fact that the silk cursor does not block completely the view of any object which it occludes, due to the fact that it is semi-transparent. In essence, therefore, we contend that not only are important enhancements of depth perception to be gained through application of occlusion cues, but the one clear disadvantage of complete occlusion is greatly diminished – namely, the fact that all information about objects being obscured by an opaque intervening object is necessarily lost, For such practical computer- related applications as pursuit tracking, docking, target acquisition, etc., this is expected to present a significant advantage.

CONCLUSION

We have proposed a semi-transparent silk volume cursor, to serve as a novel technique for performing target acquisition type tasks in 3D environments. Within the context of a carefully designed "virtual fishing" experiment that represented a dynamic 3D target acquisition task, the silk volume cursor demonstrated superior performance over a comparable wire frame cursor, both in stereo and in mono display modes.