A USER STUDY EVALUATING LEVEL OF DETAIL DEGRADATION IN THE PERIPHERY OF HEAD-MOUNTED DISPLAYS

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Summary

The efficacy of degrading level of detail (LOD) in the periphery of the head-mounted displays was evaluated. Results indicate that this sort of LOD degradation can be quite effective.

A User Study Evaluating Level of Detail Degradation in the Periphery of Head-Mounted Displays

Many researchers have identified slow frame rates and large latencies as two of the most pressing facing the virtual environments (VE) community. Foremost among the proposed solutions to these problems is the idea of varying level of detail (LOD). Both Funkhauser & Séquin (1993) and Maciel & Shirley (1995) have implemented systems that attempt to degrade LOD in the periphery of the visual field. However, because both systems assume that the eyes are focussed on the center of the image, they might more accurately be said to degrade LOD in the image periphery.

We performed a user study that investigated the value of this technique when used in head-mounted displays (HMDs) with head motion tracking. After focussing on a home object, subjects pressed a button to begin the search task. The home object disappeared, and a single target appeared outside the subject's view. Subjects located the target object and pressed one of two buttons to indicated if the object was labelled with a number or letter. Subjects performed the search task in seven different display types. Each of these display types was a combination of the two main independent variables: peripheral resolution and high LOD inset size. Each of these variables was varied within subjects at three possible levels, as shown in Table 1. Figure 1 shows a large LOD inset with a low resolution periphery. Target location was controlled through the use of nine regions located around the subject, as illustrated in figure 2. Order of display presentation, button configuration, and many other variables were also controlled.

Table 1:
The seven display types. Performance with a display is shown as means and standard deviations for both user accuracy (percentage correct) and search time (seconds on correct searches).

	Accuracy (pctg)		Srch Time (secs)	
Display Type	**Mean**	**Std Dv**	**Mean**	**Std Dv**
No inset, hi res	95.7%	6.74	2.652	0.793
No inset, med res	94.8%	6.84	2.863	0.878
No inset, low res	80.3%	12.85	3.490	0.993
Lg inset, med res periph	95.9%	6.11	2.986	0.825
Lg inset, low res periph	94.6%	6.90	3.146	0.930
Sm inset, med res periph	94.5%	6.90	2.727	0.790
Sm inset, low res periph	94.9%	8.08	3.097	1.033

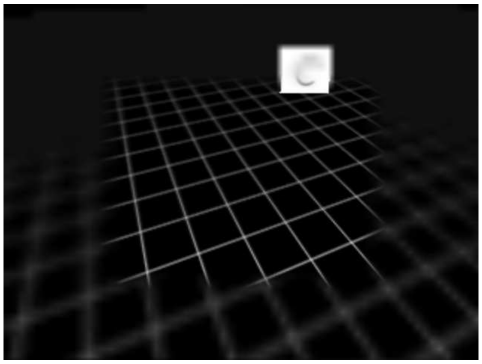

Figure 1: view of target object labelled with "C" in large inset, low resolution periphery display type.

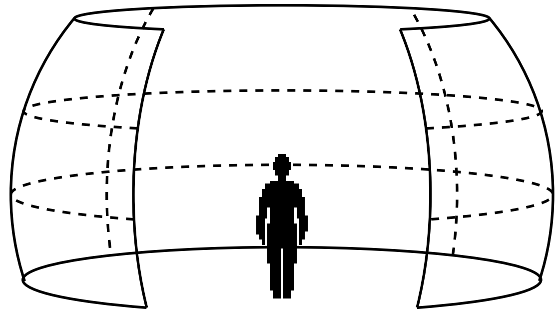

Figure 2: the search space sphere around subjects was divided into nine regions of equal surface area.

As dependent measures, we used letter/number identification accuracy, and search time in trials with correct identifications. For both measures, display type by region ANOVA indicated significant effects of display type ($p < .001$), without significant interaction with regions. Bonferroni pair-wise comparisons revealed that only the low resolution, insetless display was significantly different from other displays.

Results indicated that peripheral LOD degradation is a useful compromise. The display type with the lowest LOD -- an insetless, low resolution display -- was significantly worse than an insetted display, even if the insetted display used low peripheral resolution. At the same time, the display type with the highest LOD -- an insetless, high resolution display -- was not significantly better than insetted displays of any type. The fact that these results were achieved without eye tracking is particularly interesting, and suggests that eye tracking may be of little importance in HMDs when the high LOD inset is not extremely small. While the results have very adequately revealed the gains to be made by the addition of high LOD insets to low LOD views, they say little about the cost of subtracting high LODs from view peripheries. In a follow-up experiment, we have increased task and environment complexity in order to examine these issues more closely.

References

Funkhauser, T. & Séquin, C. (1993). Adaptive display algorithm for interactive frame rates during visualization of complex virtual environments. *Computer Graphics, SIGGRAPH 93 Conference Proceedings*, August, pp. 247-254.

Maciel, P. & Shirley, P. (1995). Visual navigation of large environments using textured clusters. *Proceedings 1995 Symposium on Interactive 3D Graphics*, April, pp. 95-102.