Perceptual Gaze Extent & Level Of Detail in VR: Looking Outside the Box

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A common assumption exploited in perceptual Virtual Reality studies is that eye movements made while immersed in VR generally do not deviate more than 30° (visual angle) from the head-centric view direction (e.g., see Barnes [1979]). In this sketch we report eye tracking evidence which generally supports this observation in the context of peripheral Level Of Detail management during a visual search task in VR. We present results from experiments based on the work of Watson et al. [1997] and discuss an extension to the peripheral degradation paradigm to include a dynamic eye-slaved high-resolution inset.

Experimental Techniques

To investigate perceptual gaze extent in VR, we began by replicating the experiments of Watson et al., where the objective of the study was the evaluation of peripheral degradation for bandwidth reduction during a visual search task. Watson et al. found that a static high-resolution window of 30° in a low-resolution 75.3° × 58.4° visual field does not impede visual search performance (when compared to search in an undegraded environment). To quantify eye movement behavior under this condition, we use a binocular eye tracker mounted in an HMD (see Murphy and Duchowski [2001]). We then extend the static-window paradigm by synchronizing the high-resolution inset to the real-time location of the participant's gaze. Five trials were conducted for each of seven combinations of inset size and varying level of background degradation. This was repeated for both stationary and mobile insets resulting in 70 trials per subject. Eight subjects participated, varying in age from 22 to 53, with normal or corrected to normal vision.

Results and Analysis

In accordance with Watson's results, we found that a medium-sized high-resolution inset ($< 30°$) is required before search performance is impeded in a low-resolution scene. During this task, as shown in Figure 1, 70% of all fixations made by subjects fall within 30° (as indicated by the superimposed box). Our data shows that eye movements may extend as far as approximately 43°, consistent with Watson's assumption (based on the work of Barnes).

Since we found that windows smaller than 30° affect performance in a coarsely degraded field, we also investigated the use of an eye-slaved high-resolution inset. Figure 2 shows average trial search times. The first trial pair shows search times in a high-resolution field (no distinguishable inset or degradation). The next three trial pairs show no clear advantage of either the stationary or mobile insets. Surprisingly, two of the last three trial pairs show that search performance decreases when the high-resolution inset is synchronized with gaze direction.

Discussion

Our eye tracking work offers supporting evidence of perceptual gaze extent roughly limited to 30° during visual search in VR. This suggests that eye movements made outside the 30° box do not seem to affect search performance, i.e., subjects *look* but don't *see* outside the box. Furthermore, performance appears to suffer under extreme degradation conditions with a small, eye-slaved high-resolution inset. This may be due to either system lag, eye tracker inaccuracy, or imposition of interface control (gaze-controlled movement of the inset) on a perceptual organ. We are continuing our analysis in order to disambiguate the latter point.

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References

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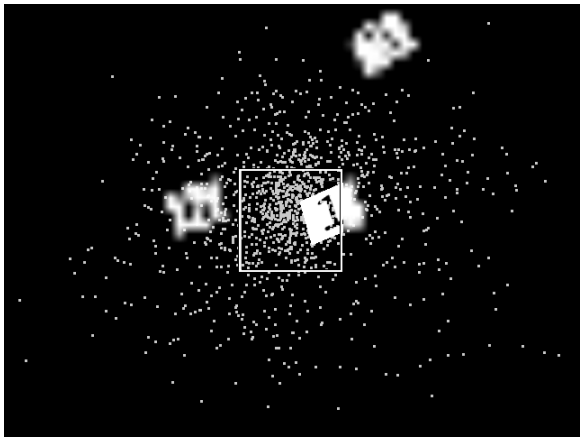

Figure 1: Fixations over an example search environment.

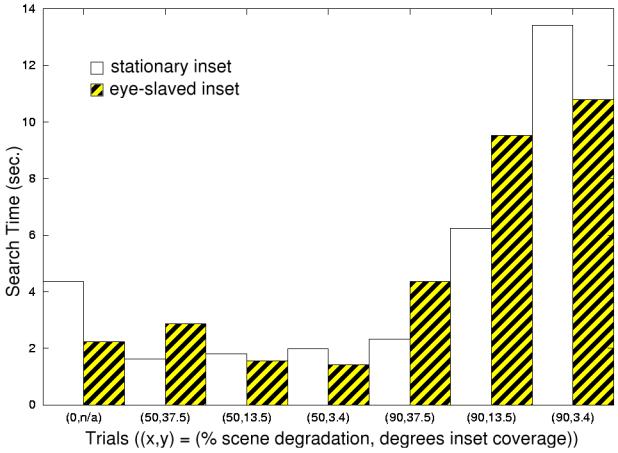

Figure 2: Average trial search times.