Foveated 3D Display

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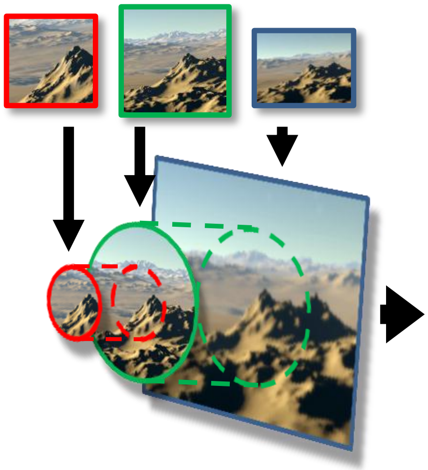

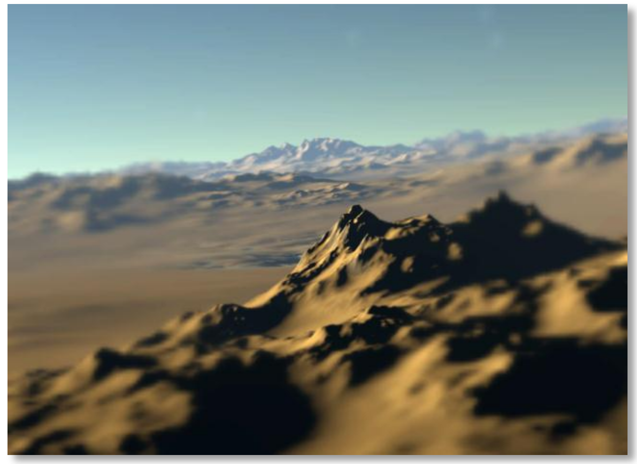

Figure 1: *Foveated rendering. Three low-resolution image layers centered about the viewer's current gaze position, as determined by the eye tracking hardware, are composited together to create the high-resolution final frame. The inner layer, highlighted here in red, matches the screen's pixel density but covers only a tiny fraction of it. The middle layer, outlined in green, covers a larger area at half the pixel density in each dimension. The background layer, outlined in blue, covers the entire screen at a very coarse resolution. Careful but inexpensive antialiasing prevents distracting artifacts in the periphery and maintains the "hi-res everywhere" illusion.*

1. Introduction

Humans see at high resolution only within a few degrees of the direction we are looking. Moving our gaze position around the current scene, we build up the rich visual landscape we consider reality from a sparse set of details, filled in with coarser data from our peripheral vision.

Traditional display systems don't know where the user is looking and so must render at uniformly high resolution. Consumer demands to raise graphics quality while lowering hardware weight and power consumption suggest that this obvious inefficiency will not persist indefinitely.

We exploit the foveated nature of the human visual system by combining 150 years of psycho-visual research, newly maturing eye tracking technology, and careful antialiasing and compositing techniques on the GPU. User studies have verified that our system provides quality equivalent to traditional display while rendering a factor of 10 to 15 fewer pixels, and achieving an overall speedup of a factor of 6 to 8.

2. System Description

Our system uses commodity hardware to track the viewer's gaze position. Each frame the scene is rendered three times (see Figure 1). Two inner layers are centered at the current gaze position, and a third outer layer fills in the periphery. The three layers are then composited together smoothly to approximate the more continuous falloff of acuity away from the gaze position.

The system can be tuned to match acuity falloff as predicted by the psycho-visual literature. We can also push performance at the expense of visual quality in the periphery, to explore more subjective evaluations of "good enough".

Figure 2: *The tracker follows user gaze position which governs rendering to this extremely high-resolution 3x3 monitor array.*

3. Conclusions

Exploiting foveation has long been a holy grail in computer graphics: promising but practically elusive. Presenting this work at Emerging Technologies would let the CG community experience our system for themselves, to judge the benefits and quality of foveated display. It can seem incredible that rendering which to bystanders looks so blurry in the periphery looks quite normal to the person being tracked. The experience is both startling and convincing.

References

GUENTER, B., FINCH, M. DRUCKER, S. TAN, D., AND SNYDER, J. 2012. Foveated 3D Graphics. In *ACM Trans. Graph. 26* (Nov.).

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