EE367 Project Proposal
Dynamic Gaze-Based Foveated Rendering

Sanyam Mehra, Varsha Sankar
{sanyam, svarsha}@stanford.edu

MOTIVATION

The rapidly growing popularity of Virtual Reality (VR) amongst research and commercial communities has led to computational needs for rendering systems to grow faster than the advances in graphics hardware. Head mounted displays (HMD) for virtual reality (VR) have increased screen resolution and target refresh rates. In addition, the growing trend towards rendering on devices like portable gaming consoles, smartphones and tablets motivates the goal to minimize computation while maximizing image quality. This is where the fact that humans' visual acuity decreases radially from the fovea to the eye's periphery, becomes interesting. Foveated Rendering is the idea to exploit this phenomenon in order to render the full details where the viewer's gaze is focused at, and decrease details progressively away from that point, thus leading to significant computational savings. Ideally, the implementation would be imperceptible to the viewer by preserving parts that humans perceive at the edges of their vision; color, contrast, edges (and motion). Various approaches have been tried to achieve this and we plan on implementing and evaluating Foveated Rendering using a large desktop / LCD (2D) monitor display for this project instead of an HMD.

RELATED WORK

Work has been done in creating foveated rendering algorithms. Some related work exploits foveation without eye tracking by assuming the user looks at the center of the screen [1] or by using a content-based model of visual attention [2], [3]. Such models have statistical validity across time and different users, but do not account for where the user will look at every instant. In [4] they degrade the resolution of peripheral image regions to help in real time transmission of data as well as improve realism of displayed content. In [5] they utilise foveated rendering to achieve computing workload efficiency. In [6] Microsoft Research achieved graphics computation optimization by a factor of 5-6 on a desktop HD display (1920×1080). In [7] NVIDIA tackled the effect of perceptible flickering in peripheral vision, and the 'tunnel-vision effect'.

PROJECT OVERVIEW

In this project, we aim to perform gaze-based foveated rendering of the display. We plan to use a gaze-tracker to track the gaze of the viewer looking at a 2D image on a large LCD monitor and produce a foveated rendering of the image by retaining high resolution at the region where the person's gaze is fixated, while progressively blurring the periphery. Simple blurring of the image picked up by the eye's peripheral region would reduce contrast and result in an effect called 'tunnel vision'. Thus, we plan to explore implementation of blurring with contrast preservation. This

exploits the characteristics of the human visual system that the foveal vision is sharp and detailed while peripheral vision has a larger field of view and lacks acuity.

TIMELINE/MILESTONES

- Milestone 1 (2/15 - 2/21)
    - Get familiar with the eye-tracker API.
    - Read papers on different foveated rendering algorithms.
- Milestone 2 (2/21 - 3/5)
    - Implement foveated rendering techniques for displaying 2D images.
    - Incorporate input from eye-tracker for dynamic foveated rendering.
- Milestone 3 (3/5 - 3/10)
    - Stretch goal: Extend to videos.
- Milestone 4 (3/10 - 3/16)
    - Analyze the results obtained and create demo.
    - Make poster and write report.

REFERENCES

[1] Funkhouser, Thomas A., and Carlo H. Séquin. "Adaptive display algorithm for interactive frame rates during visualization of complex virtual environments." *Proceedings of the 20th annual conference on Computer graphics and interactive techniques*. ACM, 1993.

[2] Yee, Hector, Sumanita Pattanaik, and Donald P. Greenberg. "Spatiotemporal sensitivity and visual attention for efficient rendering of dynamic environments." ACM Transactions on Graphics (TOG) 20.1 (2001): 39-65.

[3] Horvitz, Eric, and Jed Lengyel. "Perception, attention, and resources: A decision-theoretic approach to graphics rendering." *Proceedings of the Thirteenth conference on Uncertainty in artificial intelligence*. Morgan Kaufmann Publishers Inc., 1997.

[4] "Duchowski, Andrew T., Nathan Cournia, and Hunter Murphy. "Gaze-contingent displays:
A review." CyberPsychology & Behavior 7.6 (2004): 621-634.

[5] Pai, Yun Suen, et al. "GazeSim: simulating foveated rendering using depth in eye gaze for VR." *ACM SIGGRAPH 2016 Posters*. ACM, 2016.

[6] Guenter, Brian, et al. "Foveated 3D graphics." *ACM Transactions on Graphics (TOG)* 31.6 (2012): 164.

[7] Patney, Anjul, et al. "Perceptually-based foveated virtual reality." ACM SIGGRAPH 2016 Emerging Technologies. ACM, 2016.