EE 367 Project Proposal

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Enhanced Attenuation-Based 3D Display

This project will be combined with the final project for CS 348V: Visual Computing Systems.

MOTIVATION

Unlike traditional 2D displays, attenuation-based 3D displays enable the accurate, high-resolution depiction of motion parallax, occlusion, translucency, and specularity.

RELATED WORK

We have already implemented iterative tomographic reconstruction for image synthesis on a stack of spatial light modulators (multiple low-cost iPad LCDs).

In particular, we consider four types of 3D display technologies that stand in contrast to what we have produced: parallax barriers, integral imaging, volumetric displays, and holograms. What relates these technologies is their shared ability to replicate disparity, motion parallax, and binocular depth cues without the need for special eyewear.

A performance summary of these comparative technologies based off the results of [Wetzstein et al. 2011] can be found below:

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	volumetric	integral imaging	parallax barrier	holographic
2D Resolution	high	low	low	high
3D Resolution	high	moderate	moderate	high
Brightness	high	high	low	high
Contrast	moderate	moderate	moderate	high
Complexity	high	low	low	high

Multi-layer displays present a fifth class of displays. Differing from volumetric displays with light-emitting layers, overlaid attenuation patterns allow objects to appear beyond the display enclosure. We compute these patterns using tomographic techniques to create a 4D light-field illuminated by a uniform backlight (see below). The benefit of a multi-layered display is that it possess high resolution and contrast with only moderate trade-offs in brightness and complexity. Since our display relies only on two layers and the reconstructed light-fields are precomputed, we mitigate these limitations, although the produced image is merely static. Additionally, the stacked LCD configuration relies on multiplicative light absorption, rather than additive absorption; the benefit of this is that the display can construct occlusion, specularity, and depth without the need for any moving components.

PROJECT OVERVIEW

• Strong Backlighting

Our present and near future prototypes target the desktop / fixed display form factor, where we are less constrained by power and form factor (vs. mobile devices). We are developing a much more powerful (10-100x lumen output) directional backlighting system, which we hope will significantly improve usability and enable other techniques that usually cost too much light (i.e. reduce transmissivity).

• Dynamic Rendering (Not time-multiplexing, really just running the OpenGL code)

Currently, our model is designed for static scenes only, mostly constrained by a lack of compute to render dynamic scenes in real time. Very cursory profiling suggests that significant speedups to the rendering pipeline should be possible, so we intend to write a more optimized, GPU-accelerated renderer targeting 30-60fps scene display.

• Face-Tracking

Having a good estimate of the observer's position allows aggressive rendering optimization, reducing computational cost and potentially improving solutions to the light field. We initially plan to use a standard web camera and OpenCV software running on the render host, but intend to move to a tightly embedded "RealSense" stereo camera that additionally provides depth annotations, letting us further optimize our target light field for the viewer.

PROPOSED MILESTONES

Week 6: Get OpenGL code to run at full resolution on our displays; get quarter-wave plate and backlight.

Week 7: Implement dynamic rendering + based on 3D position; Align display pixels in software.

Week 8: Interface with realsense for face tracking.

Week 9: Integrate face tracking into rendering algorithm.

Week 10: (Presentation, Tuesday Mar 13) continue rendering optimizations CS 348V (due 1 week later).

REFERENCES

[1] G. Wetzstein, D. Lanman, W. Heidrich, R. Raskar. Layered 3D: Tomographic Image Synthesis for Attenuation-based Light Field and High Dynamic Range Displays. Proc. of SIGGRAPH 2011 (ACM Transactions on Graphics 30, 4), 2011.

[2] G. Wetzstein, D. Lanman, D. Gutierrez, M. Hirsch. Computational Displays. ACM SIGGRAPH 2012 Course, 2012.

[3] Douglas Lanman, Matthew Hirsch, Yunhee Kim, Ramesh Raskar. Content-Adaptive Parallax Barriers: Optimizing Dual-Layer 3D Displays using Low-Rank Light Field.

[4] Matthew Hirsch, Douglas Lanman, Henry Holtzman, Ramesh Raskar. Factorization BiDi Screen: A Thin, Depth-Sensing LCD for 3D Interaction using Light Fields. ACM Trans. Graph. 2009. ACM SIGGRAPH Asia 2010. 2010.