A Compressive Light Field Projection System

Matthew Hirsch Gordon Wetzstein Ramesh Raskar
MIT Media Lab

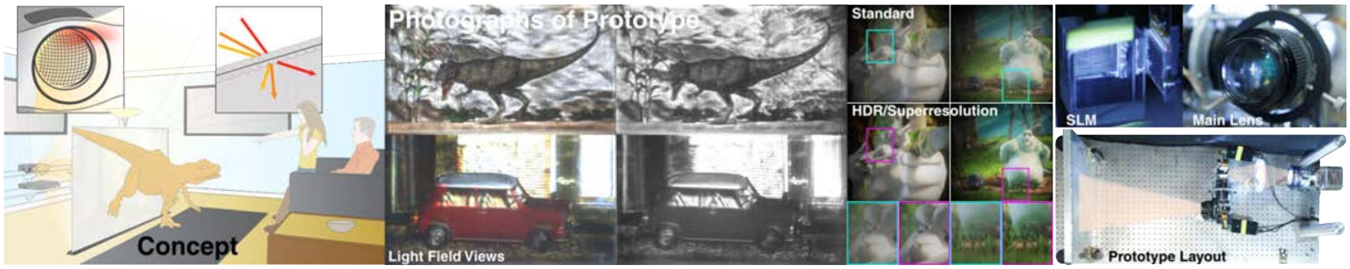

Figure 1: *Compressive light field projection for glasses-free 3D display. The system (right): a single light field projector and passive screen. The field-of-view (FOV) of the light field emitted from the projector is limited by the small size of the projection lens aperture. Keplerian telescopes inspire our screen design—the angle of incident light is expanded for an observer, creating a suitable FOV for glasses-free 3D. We achieve compressive, high-rank light field synthesis (center, left) in grayscale for human observers, and HDR and superresolved 2D images with the same projection hardware on a standard screen (center, right) using high speed (240Hz) spatial light modulators. Color imagery is obtained by compositing multiple photos and cannot be seen live.*

Abstract

Researchers and experimentalists have strived to bring glasses-free 3D to the big screen. Though light field projection systems are now commercially available, unfortunately they employ dozens of devices. They are costly, energy inefficient, and bulky. We present a compressive approach to light field synthesis for projection devices. We propose a novel, passive screen design inspired by angle-expanding Keplerian telescopes. Combined with high-speed light field projection and nonnegative light field factorization, we demonstrate compressive light field projection with a single device. Our prototype can alternatively display super-resolved and high dynamic range 2D images on a conventional screen.

1 Vision

As 3D theaters become popular, many have found watching 3D movies on large screens more immersive than conventional 2D movies or 3D content on small TVs. However, commercial stereoscopic 3D projection technology, delivered through special glasses, can create viewer discomfort. Furthermore the correct perspective is only observed from a single central sweet-spot in the theater.

We envision future commercial and home theaters that provide immersive, physically correct views for a wide range of perspectives without special glasses. In the last century inventors have investigated large-scale light field projection systems [Funk 2012]. Light field movie theaters opened to the public in Russia and France in the 1940s! These and subsequent installations employing large parallax barrier-type screens suffer from severe loss of image resolution and brightness. Commercially available light field projection systems today require dozens of devices [Balogh 2006], making them expensive, power hungry, bulky, and difficult to calibrate.

Inspired by advances in compressive light field display [Wetzstein et al. 2012], we present the first compressive light field projection system. The proposed system combines a novel, passive screen, a single high-speed light field projector, and light field factorization algorithms. Low rank factorization routines exploit redundancy in target content, compressing light field representations and also reducing required projection devices. The proposed system is therefore compressive computationally and optically.

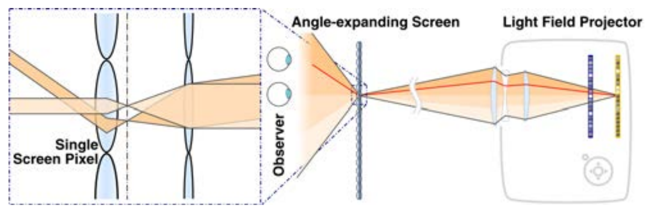

Figure 2: *The optical system comprising the screen and light field projector. The screen, inspired by Keplerian telescopes, compresses a wide field-of-view light field into the projector aperture.*

2 Compressive Optics/Compressive Display

Our prototype light field projector and passive rear-projection screen (Fig. 1) enable 3D display by expanding narrow angular variation across the aperture of a projection lens into a wider FOV light field. While our screen design supports input from any variety of light field projector, our prototype is constructed using a compressive high-rank dual layer design with high speed modulators [Lanman et al. 2010]. The screen itself comprises back-to-back lenticular sheets forming an array of angle-expanding Keplerian telescopes.

References

BALOGH, T. 2006. The HoloVizio System. In *Proc. SPIE 6055*, vol. 60550U.

FUNK, W. 2012. History of Autostereoscopic Cinema. In *Proc. SPIE 8288*, vol. 82880R.

LANMAN, D., HIRSCH, M., KIM, Y., AND RASKAR, R. 2010. Content-Adaptive Parallax Barriers: Optimizing Dual-Layer 3D Displays using Low-Rank Light Field Factorization. *ACM Trans. Graph. (SIGGRAPH Asia) 28*, 5, 1–10.

WETZSTEIN, G., LANMAN, D., HIRSCH, M., AND RASKAR, R. 2012. Tensor Displays: Compressive Light Field Synthesis using Multilayer Displays with Directional Backlighting. *ACM Trans. Graph. (SIGGRAPH) 31*, 1–11.

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