Tensor Displays

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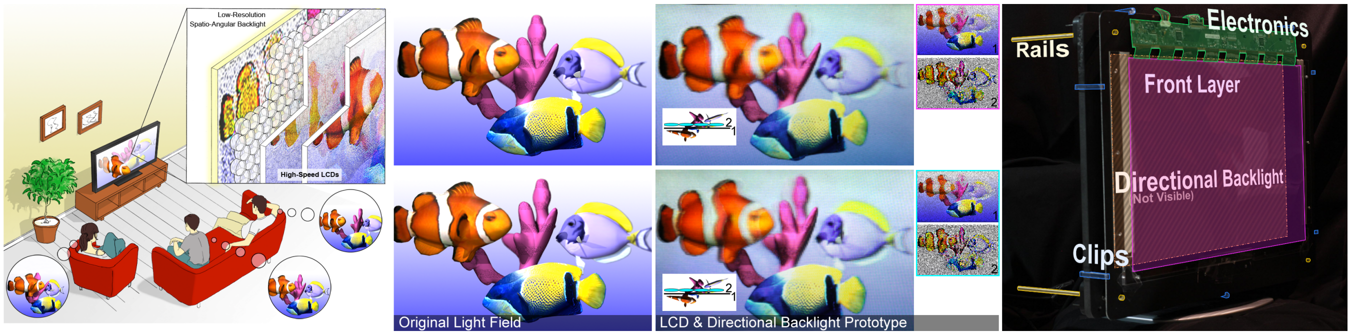

Figure 1: *Wide field of view glasses-free 3D imagery on tensor displays. (Left) A new family of light field displays (tensor displays), comprising stacks of light-attenuating layers (e.g., LCDs). Rapid temporal modulation of the layers and directional backlighting allows large separation between viewers. (Center) Target light field view (rendered), and tensor display (photograph). Layers are shown to the right of each photograph. Rows depict perspectives seen to the left and right of the display. (Right) Directional backlight tensor display hardware. A rail and clip system accurately positions an LCD in front of a directional backlight.*

Abstract

We introduce tensor displays: a family of light field displays comprising all stacked display architectures employing light-attenuating layers illuminated by uniform or directional backlighting (i.e., any low-resolution light field emitter). Tensor displays include the capability to time-multiplex content across frames on each of the layers to improve image quality. We show that the light field emitted by an N-layer, M-frame tensor display can be represented by an N^{th}-order, rank-M tensor. In a related technical paper submission, we use this representation to introduce a unified optimization framework, based on nonnegative tensor factorization (NTF), encompassing all tensor display architectures (see supplementary supporting document). In this emerging technologies demonstration, we show both static, printed tensor displays, and dynamic LCD-based systems, providing wide field-of-view, bright, high-resolution, glasses-free 3D display.

1 Vision

Consumer stereoscopic displays have been enabled by the introduction of high-speed LCDs and inexpensive shutter glasses. Manufacturers are beginning to offer automultiscopic (glasses-free) 3D displays, primarily based on the century-old concepts of parallax barriers and integral imaging. Products based on these methods have met limited commercial success due to intrinsic limitations of the approaches, particularly narrow fields of view and reduced spatial resolution. We are inspired to address the limitations of existing automultiscopic displays by taking advantage of three emerging display technologies: multilayer panels, high-speed temporal modulation, and directional backlighting, in combination with efficient high-speed GPU processing.

2 Tensor Display Framework

Our tensor display framework is the first to allow joint multilayer, multiframe light field decompositions, significantly reducing artifacts observed with prior multilayer-only and multiframe-only decompositions [Lanman et al. 2010; Lanman et al. 2011; Wetzstein et al. 2011]; it is also the first optimization method for designs combining multiple layers with directional backlighting.

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SIGGRAPH 2012, Los Angeles, California, August 5 – 9, 2012.
ISBN 978-1-4503-1435-0/12/0008

3 Prototypes

We show two prototype tensor displays. Static scenes can be created cheaply using stacked layers of printed transparent sheets. By constructing a dynamic, reconfigurable prototype using modified LCD panels and a custom integral imaging backlight, we improve display quality through time-multiplexing, and show video content. Our efficient, GPU-based NTF implementation enables interactive applications. Prototype tensor displays reveal practical architectures with greater depths of field, wider fields of view, and thinner form factors, compared to prior automultiscopic displays.

4 Conclusion

Automultiscopic displays have not found widespread consumer adoption. While compelling multiview content is first necessary, long-standing optical and algorithmic limitations must be conclusively resolved. Viable solutions must preserve the thin form factors, low power consumption, and high resolution of modern displays, using near-term, mass-market technology. Tensor displays provide the first framework combining the advantages of three key multiview display trends: multilayer panels, high refresh rates, and directional backlighting. This framework exemplifies emerging *computational displays*, wherein the display architecture and encoding algorithm are jointly optimized to maximize optical and computational efficiency.

References

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