Lumii: DIY Light Field Prints

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Lumii

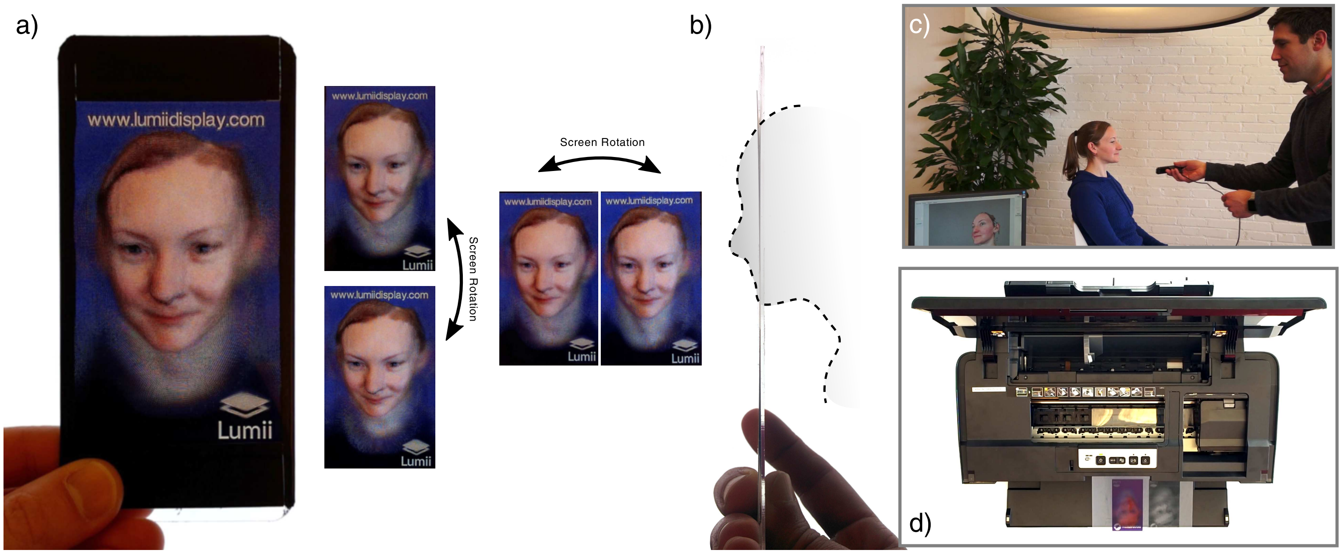

Figure 1: *Realistic, high-resolution light field displays (also known as glasses-free 3D or autostereo displays) (a) can now be created with tools readily available to graphics researchers and hobbyists, including depth cameras (c), photo printers (d), and commodity GPUs thanks to optimization-based techniques. Our technology enables unprecedented resolutions and pop-out-to-thickness ratio (b, side view of a).*

Abstract

In this emerging technology demonstration, we show that computational display methods can be used to create hologram-like 3D images on thin, printed surfaces using standard inkjet processes. Participants will receive a light field print of their own 3D-scanned face, created on-site using an inkjet printer. The computed patterns used in creating the print will also be made available to attendees, who will be able to create additional copies at home. The demonstration uses methods that represent a major step forward in the lineage of results presented previously at SIGGRAPH regarding the close integration of light field displays and optimization methods, which have previously been shown to outperform holograms as well as lens-based discretized light field displays in complexity and cost. The enabling innovation behind the demonstration is an improvement in both resolution and pop-out-to-thickness ratio, which allows for printed light field display surfaces that are a fraction of the thickness of the virtual image being displayed.

Keywords: compressive displays, light fields, diy
Concepts: •**Mathematics of computing** → *Discrete optimization;* •**Hardware** → *Displays and imagers; Printers;*

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SIGGRAPH '16, July 24-28, 2016, Anaheim, CA,
ISBN: 978-1-4503-4373-2/16/07
DOI: http://dx.doi.org/10.1145/2929484.2929487

1 Vision

A long-standing vision of the display research community has been to create display surfaces with fidelity that is indistinguishable from reality. Our research is aimed at making progress toward this goal, in particular by creating high-resolution automultiscopic light field displays capable of full horizontal and vertical parallax. Emerging from this research is a user-facing light field engine, inspired by computational display research from the SIGGRAPH community, that can be used to generate thin, hologram-like light field prints using a standard inkjet printer.

Along with the thriving 3D printing and 3D capture ecosystems, a nascent 3D display ecosystem is developing. Technologies to capture, create, and print 3D content have become nearly ubiquitous in the last few decades, but there remains a glaring inability to create accompanying glasses-free 3D visualizations with hardware available at a consumer and hobbyist level. Optimized light field displays that put inexpensive, high-quality, print and digital displays in the hands of users will create exciting opportunities in human computer interaction, 3D printing and manufacturing, medical diagnostics, media and advertisement, augmented reality, artistic expression, and beyond.

2 Background

Creating a light field display with comparable image resolution to a 2D display in a convenient form factor is a challenging problem. For over a century researchers and practitioners have created displays that use brute force spatial and angular sampling schemes using light modulating materials [Ives 1903], often requiring special purpose optics [Lippmann 1908]. The sampling schemes of such displays create a spatioangular trade-space that results in spatial

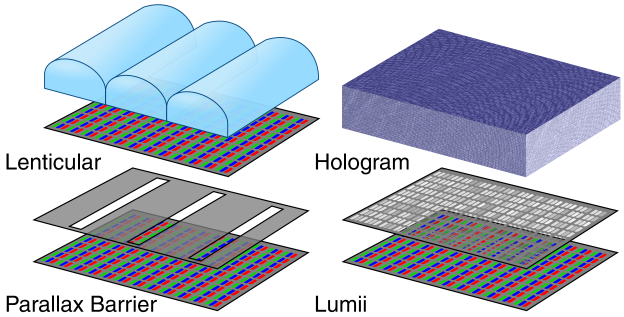

Figure 2: *Popular light field display hardware. Clockwise from top left: lenticular lenses, holograms, Lumii optimized displays, and parallax barriers. Note that Lumii displays use two standard print layers, and are structurally different than parallax barrier displays.*

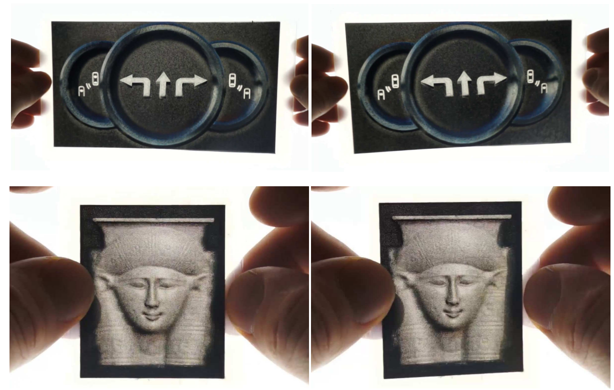

Figure 3: *Additional prints will be available for viewing at the emerging technology booth. See the supplemental video for an animated look at these examples. Image pairs (middle, bottom) are arranged for crossed-eye viewing.*

blur and narrow depth-of-field.

Full-color white-light reflection holograms provide superb image quality but their production is restricted to expert users and delicate, expensive hardware. Holographic stereograms create discretized spatioangular holographic samples called hogels, and can also achieve impressive pop-out effects. However, state-of-the art [Klug et al. 2001] prints cost hundreds of times more than a color photo print, are limited to a pixel pitch of about $1mm$, and cannot be printed on-site: a critical requirement for many office and remote work site applications.

In recent SIGGRAPH conferences there has been a resurgence of 3D display research that uses formal optimization methods to adapt light field display sampling to content [Lanman et al. 2010] and viewer position [Maimone et al. 2013], allowing for improved image quality using commodity and novel display optics [Lanman et al. 2011; Wetzstein et al. 2012], and enabling new applications such as 3D projectors [Hirsch et al. 2014], accommodation-supporting near-eye displays [Huang et al. 2015], and inkjet prints [Wetzstein et al. 2011]. This research thread has opened the possibility for light field displays with properties that rival holograms using inexpensive ray-based optical devices and analysis.

Lumii has refined the computational display techniques necessary to create high-quality printed and digital displays. Lumii prints can be very thin and bright (Figure 1a,b), and the spatial resolution of in-plane objects can match the native resolution of the display medium.

3 3D Printing Your Face: A Lumii Demo

During the SIGGRAPH 2016 Emerging Technologies showcase, Lumii will present a different take on 3D printing. Conference attendees will be able to have their face (or other objects) scanned using a commodity depth camera such as the Microsoft Kinect One, Intel Realsense F200, or Structure Sensor (Figure 1c). The output will be processed by Lumii's light field engine, and printed as a hologram-like 3D film that attendees will be able to take home with them. The printing process will use commercially available photo printers (Figure 1d). High resolution photo printing can take up to 15 minutes. Attendees will be able to return at a later time to pick up their prints. Further, emerging technologies attendees will be given the option to retrieve the print patterns at a later time to reprint their Lumii prints at home.

Additional examples of Lumii displays will be available at the Lumii emerging technology booth. Attendees will gain a sense of the design space and capabilities of the next generation of computational light field displays.

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