An Autostereoscopic Projector Array Optimized For 3d Facial Display. ACM SIGGRAPH 2013 Emerging Technologies, New York, NY, Article 3, 1 page, 2013.

An Autostereoscopic Projector Array Optimized for 3D Facial Display

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Figure 1: *Our projector array (left) generates autostereoscopic views of a virtual character (middle) and 4D facial performance capture (right)*

Introduction Video projectors are rapidly shrinking in size, power consumption, and cost. Such projectors provide unprecedented flexibility to stack, arrange, and aim pixels without the need for moving parts. We present a dense projector display that is optimized in size and resolution to display an autostereoscopic lifesized 3D human face with a wide 110 degree field of view. Applications include 3D teleconferencing and fully synthetic characters for education and interactive entertainment.

Related Work The commercial company Holografika has demonstrated various large-format screens up to $3m$ across with up to 80 large-format projectors [Balogh et al. 2007] but does not publish their projector specifications, diffusion materials, calibration process, or rendering algorithms, and has not specifically demonstrated the concentrated spatial and angular resolution for convincing autostereoscopic display of an interactive face. Our display is reproducible with off-the-shelf components, and a central goal of our E-Tech exhibit will be to show how such a display can be constructed easily and run from a single computer to encourage research in the field.

Projector Array Design Our display utilizes 72 Texas Instruments DLP Pico Projector Development Kit v2.0 devices to illuminate a $30cm \times 30cm$ anisotropic screen, and we removed the cases and built custom mounts to place the projectors just 14mm apart. We use the horizontal cylindrical ridges of a plastic 40 lineper inch lenticular screen painted black on its back side to achieve the anisotropic reflection with a high contrast ratio in ambient light. The light from each projector lens reflects back as a vertical strip of light, so to blend the lines together we use a 1° horizontal by 60° vertical light-shaping diffuser sheet from Luminit, which also increases the vertical diffusion. We wrote a GPU simulator program to show the effect of different projector array shapes, amounts of diffusion, and projector densities, which led us to place the projectors in a $124cm$ curve with a radius of $60cm$ to maximize the depth of field. We also prototyped the display using a single picoprojector on a motion control arm and long-exposure photography [Jurik et al. 2011] to simulate the 3D effect with real-world equipment. Our setup provides a high angular resolution of 1.66° between views, achieving not only binocular stereo but also compelling motion parallax.

GPU rendering Notably, we drive our projector array using a single computer with twenty-four 1920×480 video outputs from four AMD FirePro W600 Eyefinity graphics cards. We then split each video signal using a Matrox TripleHeadToGo box into three 640x480 outputs, yielding the 72 projector signals. We adapted the multiperspective vertex shader technique of [Jones et al. 2007] to work with fixed projector arrays and different display surface shapes. For a given mirror shape and diffusion profile, we approximate the reflected projector positions and use them to warp vertex positions to generate multiple-center of projection images. We project a series of AR toolkit markers from each projector to calibrate the display geometrically and photometrically. As shown in the accompanying video, we can produce a stable image with correct perspective for either flat or curved display surfaces. We can also determine the ideal horizontal diffusion width by simulating different anisotropic reflectance lobes.

Vertical Parallax Our display achieves autostereoscopic horizontal parallax without lag. For faces which can make eye contact, vertical parallax is also important. Unlike other systems, we render accurate vertical parallax by detecting the viewer head positions using a Microsoft Kinect. Given the height and distance of the multiple viewers, we warp the multiperspective rendering according to who will see each column of projected pixels. An example of tracked vertical parallax rendering can be seen in the accompanying video.

Future Work Our projector array construction and calibration approach admits alternate setups, including rear-projection, and full-body projection using higher-resolution projectors placed with greater density further away from a larger screen.

References

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