High Dynamic Range 3D Display System with Projector and 3D Color Printer Output

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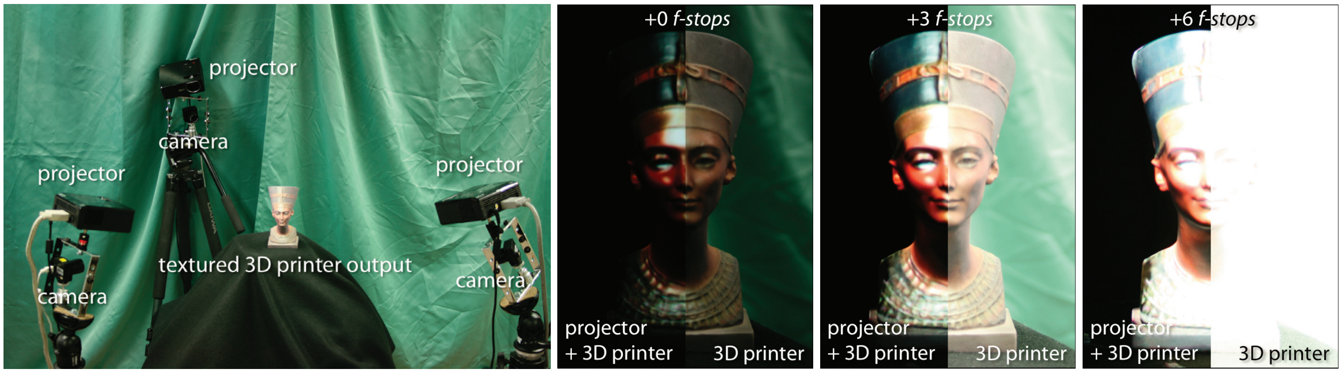

Figure 1: Superimposition of multiple projected images onto a textured 3D printer output leads to multiplicative luminance and chrominance modulation. This consequently leads to contrast enhancement. The leftmost image shows the experimental setup, and the remaining three images show the appearance of the object by the proposed method (left) and 3D printer output (when viewed under environment light) alone (right) captured under different exposures.

Abstract

This demonstration describes a new high dynamic range (HDR) display system that generates a physical 3D HDR image without using stereoscopic methods. To boost contrast beyond that obtained using either a hardcopy or a projector, we employ a multiprojection system to superimpose images onto a textured solid hardcopy that is output by a 3D printer or a rapid prototyping machine. The physical contrast ratio obtained using our method was approximately 5,000:1, while it was 5:1 in the case of viewing the 3D printout under environmental light and 1,000:1 in the case of using the projectors to project the image on regular screens.

1 Introduction

High dynamic range (HDR) display technologies allow the display of images on 2D surfaces with luminance ranging several orders of magnitude. Most of these displays are based on the principle of double light modulation using transmissive spatial light modulators, such as LCD panels [2]. On the other hand, a new approach based on reflective image modulation has been recently introduced for viewing static HDR content [1]. Images are projected onto hardcopies, such as photographs, to boost contrast beyond that obtained using hardcopies or projectors alone.

This demonstration presents a novel HDR display system that allows the generation of a physical 3D HDR image without the use of any stereoscopic methods (Fig.1). Transmissive methods cannot be used for this purpose. Because transmissive modulators are limited to planar surfaces, they display virtual 3D HDR content using a stereoscopic approach. In contrast, reflective approaches generate images by using 3D textured physical objects as hardcopies. A physical 3D HDR display is indispensable in specific applications, such as in industrial design for the assessment of a product prototype or in archeology for the realistic physical reproduction of digitally archived historic objects. In these fields, an enhanced material perception (e.g., specularity) of the displayed 3D information is required. We employ a multiprojection system to superimpose images onto a textured solid hardcopy that is output by a 3D printer or a rapid prototyping machine.

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2 Technical Approach

We introduce two basic techniques for our 3D HDR display. The first technique computes an optimal placement of projectors so that projected images cover the hardcopy's entire surface while maximizing image quality. For each combination of projector positions, we evaluate the images projected on a hardcopy surface in terms of both the reflected image quality and the degree of coverage on the basis of the geometric and photometric models of the projectors. The second technique allows a user to place the projectors near the computed optimal position by projecting from each projector images that act as visual guides. Each projector projects an image, which is generated by assuming that the projector is placed at the optimal position. The user adjusts the projector such that the projected image is registered on the hardcopy. Then, we measure the shape of the hardcopy by projecting structured light pattern, in particular gray code, from each projector. The iterative closest point (ICP) algorithm is applied to find out the actual relative position and orientation of each projector to the hardcopy. The calculated geometric information is used to generate a new projected image, which is registered on the hardcopy.

References

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