Chapter IV

Projector-Based Augmentation

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Abstract

Projector-based augmentation approaches hold the potential of combining the advantages of well-established spatial virtual reality and spatial augmented reality. Immersive, semi-immersive, and augmented visualizations can be realized in everyday environments—without the need for special projection screens and dedicated display configurations. Limitations of mobile devices, such as low resolution and small field of view, focus constrains, and ergonomic issues can be overcome in many cases by the utilization of projection technology. Thus, applications that do not require mobility can benefit from efficient spatial augmentations. Examples range from edutainment in museums (such as storytelling projections onto natural stone walls in historical buildings) to architectural visualizations (such as augmentations of complex illumination simulations or modified surface materials in real building structures). This chapter describes projector camera methods and multi-projector techniques that aim at correcting geometric aberrations, compensating local and global radiometric effects, and improving focus properties of images projected onto everyday surfaces.
Introduction

Their increasing capabilities and declining cost make video projectors widespread and established presentation tools. Being able to generate images that are larger than the actual display device virtually anywhere is an interesting feature for many applications that cannot be provided by desktop screens. Several research groups discover this potential by applying projectors in unconventional ways to develop new and innovative information displays that go beyond simple screen presentations.

Projector-based displays have clearly replaced head-attached displays for most virtual reality (VR) applications. Immersive surround screen displays and semi-immersive wall-like or table-like configurations are being used for visualizing two-dimensional or three-dimensional graphical content.

Today, the majority of augmented reality applications focus on mobility. Thus, wearable or portable devices have become dominant in this area. However, an increasing trend toward projector-based displays for AR can be noticed. Projector-based augmentation approaches hold the potential of combining the advantages of well-established spatial virtual reality and spatial augmented reality (Bimber & Raskar, 2005d). Immersive, semi-immersive, and augmented visualizations can be realized in everyday environments—without the need for special projection screens and dedicated display configurations. Limitations of mobile devices, such as low resolution and small field of view, focus constrains, and ergonomic issues can be overcome by the application of projection technology. For many applications, this requires the abdication of mobility, but not necessarily of portability. Several applications, however, do not require mobility and rather benefit from efficient spatial augmentations. Examples range from edutainment in museums (such as storytelling projections onto natural stone walls in historical buildings) to architectural applications (such as augmentations of complex illumination or surface material simulations in real building structures). The problems, limitations, potentials, and details of a variety of existing techniques toward projector based augmentations are described in this chapter.

A variety of stationary, movable, and hand-held projectors have been proposed for displaying graphical information directly on real objects or surfaces instead of performing optical overlays or video compositions.

The Luminous Room (Underkoffler, Ullmer, & Ishii, 1999) for instance, describes an early concept for providing graphical display and interaction on each surface of an interior architecture space. Co-located two-way optical transducers, called I/O bulbs, that consist of projector camera pairs capture the user interactions and display the corresponding output. With the Everywhere Displays projector (Pinhanez, 2001), this concept has been extended technically by allowing a steerable projection using a pan/tilt mirror. A similar approach is followed by Ehnes, Hirota, and Hirose (2004). Recently, it was demonstrated how context-aware hand-held projectors, so-called iLamps, can be used as mobile information displays and interaction devices (Raskar et al., 2003).

Another concept called Shader Lamps (Raskar, Welch, Low, & Bandyopadhyay, 2001) attempts to lift the visual properties of neutral diffuse objects that serve as projection screen. The computed radiance at a point of a non-trivial physical surface is mimicked by changing the bidirectional reflectance distribution function and illuminating the point appropriately with projector pixels. Animating the projected images allows creating the perception of mo-