

View-Dependent Stereoscopic Projection Onto Everyday Surfaces

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1 Motivation

We show how view-dependent stereoscopic projection on ordinary (geometric complex, colored and textured) surfaces within everyday environments is made possible. Special display configurations for immersive or semi-immersive AR/VR applications that require permanent and artificial projection canvases might become unnecessary. For different application domains –such as architecture– this approach supports ad-hoc visualizations in real environments (fig. 3 for examples). All computations (fig. 1a) are carried out in real-time on a pixel-precise basis.

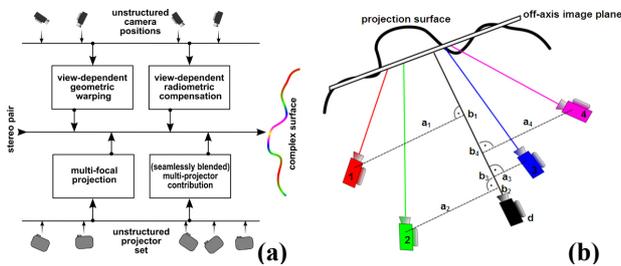


Figure 1. Pixel shader components of rendering framework (a) and image-based geometric warping (b).

2 Radiometric Compensation

If images are projected onto colored and textured surfaces, the projected light is blended with the reflecting surface pigments. This results in a composition of the projected image with the texture of the underlying display surface (fig. 2a,b). A fusion of projected stereo-pairs –and consequently a correct depth perception of the displayed three-dimensional scene– is difficult in this situation. Thus a real-time per-pixel radiometric compensation which neutralizes the bending artifacts is essential for visualizing stereoscopic imagery on textured surfaces. We use a camera in combination with projected structured light for measuring the surface reflectance as well as the contribution of the environment light. These parameters are then used for correcting the projected images in such a way that blending artifacts with the underlying surface are minimized (fig. 2c,d).

3 Geometric Image Warping

To achieve a precise registration of projector pixels and surface pigments, we measure a 2D look-up table that maps every pixel from camera space to projector space and vice versa. This is enabled by structured light techniques and allows the projection of warped images in such a way that they appear geometrically correct from the perspective of the calibration camera. All pixel-individual radiometric measurements (surface reflectivity, environment light contribution and projectors' form factor components) can also be taken for this perspective. For view-dependent applications (e.g., head-tracked stereoscopic visualizations), however, a single camera sweet spot is not sufficient. Inspired by Lumigraph rendering, multiple

measurements from unstructured camera positions can be taken (fig. 1b). Geometric and radiometric surface parameters are stored in textures. During runtime, these textures are interpolated by pixel shaders to generate adequate information for novel viewpoints. Measuring all parameters for one camera position is fully automatic and takes about 20 seconds.

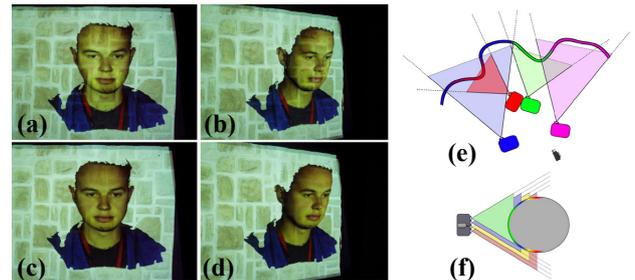


Figure 2. Stereoscopic projection onto natural stone wall (a) and multi-focal projection configurations (b).

4 Multi-focal Projection

Conventional projectors can focus on single focal planes only. Projecting onto complex 3D surfaces with varying depth causes blur effects. This washes out image features which are needed for correct disparity-based depth perception. Our basic idea for achieving a multi-focal projection is illustrated in figures 2e,f: Multiple conventional projectors with different focal planes, but overlapping images are used. They can be arbitrarily positioned in the environment (fig. 2e), or can be integrated into a single projection unit (fig. 2f). The focus error created on a surface has to be estimated for each projector pixel automatically using structured light. If this is known, a final image with minimal focus error can be composed from the contribution of all projectors during runtime. Our focus estimation techniques are suitable for complex surfaces (geometry, color and texture). The image composition methods are implemented as pixel shaders and are carried out in real-time.

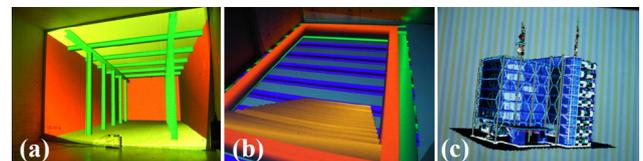


Figure 3. Ad-hoc visualizations in real architectural environments: Adjacent room (a) and stairways to lower building level (b). CAD model projected onto wallpaper in an office environment (c).

All techniques are applied together with intensity and color blending, as well as with shadow removal methods in multi-projector configurations. The examples shown in figure 3 have been set up from scratch in a non-laboratory environment in less than one hour (including calibration and hardware installations).