Applications for Multi-Planar Projected Displays

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1. Introduction

Recent advances in commodity high-resolution ultra-portable projectors have stimulated the development of a variety of novel projected displays [2]. The effort involved in manually aligning projected displays to physical surfaces has motivated research in projector-camera systems, where techniques adopted from multi-view computer vision are applied to collections of projectors and cameras. Our system employs an uncalibrated projector-camera pair to exploit the juxtaposition of planar surfaces in a room to create ad-hoc visualization and display capabilities. Figure 1 shows how a single projector and camera can enable multi-surface visualization applications.

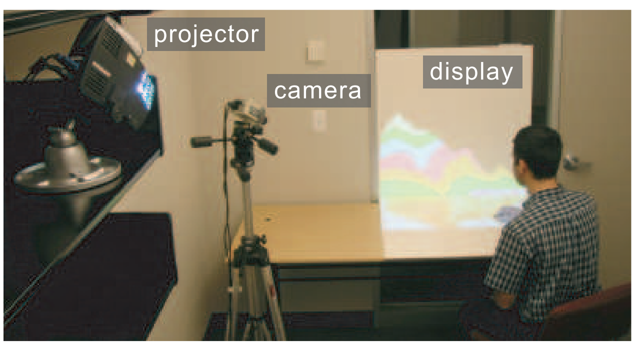

Figure 1: A multi-surface display created using a single projector. Note the oblique placement of projector and camera.

2. Calibration

The system quickly auto-calibrates the projected display with a minimum of effort on the part of the user. The key to our calibration approach is an efficient technique for simultaneously localizing multiple planes and a robust planar metric rectification method. Additional details about this technique is available in [1].

Our goal is to automatically detect, segment and calibrate a piece-wise planar scene into a set of connected surfaces that can form the basis for a multi-planar display. In the most general formulation of this problem we are given multiple projector-camera pairs in unknown locations and our goal is to form a large connected display with minimal input from the user.

Calibration consists of three stages. The first stage is the identification of planar surfaces and recovery of homographies from projector to camera through each surface. This step uses uncalibrated structured light to segment planar surfaces and a robust algorithm for estimating homographies from line correspondences. The second stage performs metric rectification and alignment to obtain the homographies from the camera to each surface. We use a rectification method based on orthogonal line pairs. The third stage iteratively refines the homographies from projector to each surface to reflect the contact constraints imposed by the intersection of pairs of surfaces. These steps are summarized in Figure 2.

3. Applications

We demonstrate two visualization applications of our display system for the two-plane configuration where a vertical plane (such as a wall or cabinet) abuts a horizontal plane (such as a floor or desk surface).

The first application (see Figure 3) takes advantage of the multi-planar setting for organizing photos in a drag and drop fashion. Each plane serves as a natural target for an image category when sorting images. As each image is moved throughout and between each plane, the exact physical dimensions and orientation of its projection remain fixed due to metric rectification of each plane's homography while enforcing geometric constraints imposed by the edge joining the planes.

The second application displays a traditional map view on the horizontal plane while the corresponding topogra-

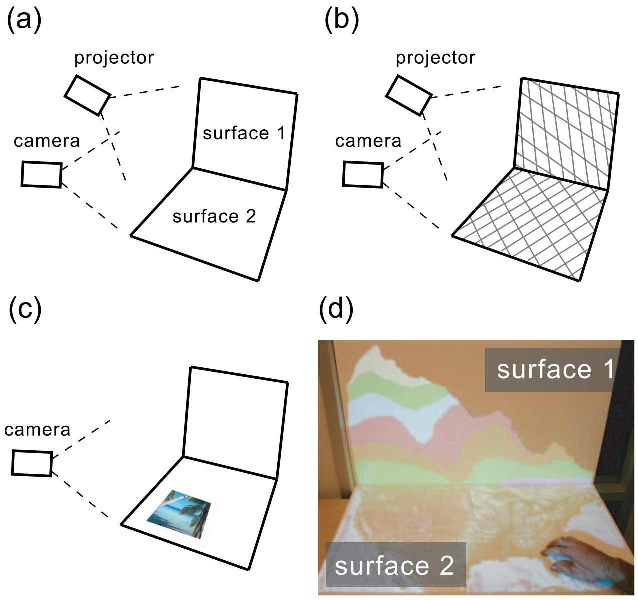

Figure 2: Calibrating a projector-camera system to a multiple surfaces. (a) The projector and camera are placed arbitrarily and the 3D geometry of the display surfaces is unknown. (b) A variant of structured light is used to find the surfaces and obtain homographies from projector to camera. (c) An everyday object is placed on the surfaces to get homographies from camera to surface. (d) The final mappings are used to create a display that spans the surfaces.

phy is provided on the vertical plane. The user can view any cross-section of the data on the vertical display simply by moving the map on the horizontal display. Because our system metrically rectifies the homography for each plane and ensures alignment between the planar displays, the user may make metric measurements from the projected displays with assurance that scale is preserved between the maps (see Figure 2-d).

References

[1] M. Ashdown, M. Flagg, R. Sukthankar, and J. Rehg. A flexible projector-camera system for multi-planar displays. In *Proceedings of Computer Vision and Pattern Recognition*, 2004.

[2] R. Sukthankar, T.-J. Cham, C. Pinhanez, and J. Rehg, editors. *Proceedings of IEEE International Workshop on Projector Camera Systems (PROCAMS-2003)*, October 2003.

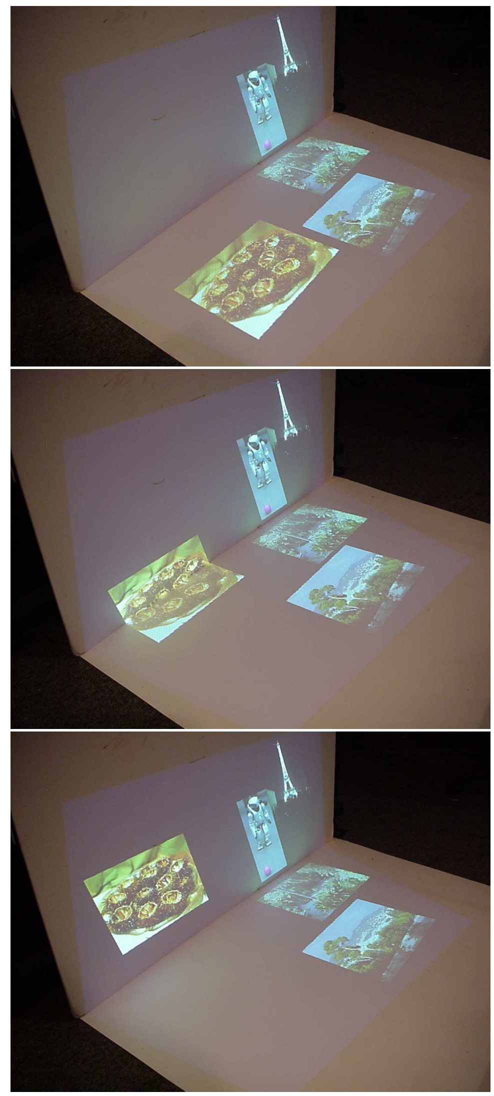

Figure 3: A photo is dragged from one plane to another in a photo-browser application that spans two surfaces.