An All-In-One Solution to Geometric and Photometric Calibration *

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(a) (b) (c) (d)

Figure 1: From calibration to augmentation. (a) Our setup. Note the complexity of the ambient lighting. (b) A raw image acquired by one of the cameras. The planar pattern on the box is automatically detected and used for calibration purposes. (c) A virtual teapot has been added. It is properly lighted and casts a shadow on the real box. (d) The virtual teapot is still correctly registered and occluded by the box even though the calibration pattern is not visible in this view.

1 Introduction

We demonstrate a simple-to-use camera calibration system that can handle multiple cameras whose fields of view do not necessarily overlap. It estimates the geometry of the cameras, their photometric responses, and an environmental lighting map. The only manual intervention required involves waving an arbitrarily textured planar pattern in front of the cameras.

In other words, in one single operation, our system yields all the information required by sophisticated Augmented Reality applications to draw virtual 3–D objects at the right locations and then light them convincingly.

Our all-in-one approach includes the following contributions that both reduce the user's workload and give our system its additional capabilities:

- **Fully automated detection of the calibration pattern**. Our approach to detecting the calibration pattern is both real-time and robust. Furthermore, it automatically selects the frames that yield the most informative homographies and rejects ambiguous ones. As a result, it becomes easy to collect large amounts of calibration data, which in turn yields excellent numerical stability and accuracy without any extra manual intervention.

- **Handling one or more cameras with non-overlapping fields of view**. Our system selects the position of the pattern that is seen by the largest number of cameras to define the common referential. It then expresses the pose of the cameras that do not see this position by composing relative displacements between camera pairs. These are easy to estimate from the homographies and give initial estimates that are then refined by bundle adjustment.

- **Photometric calibration for free**. We use the very same set of images both for geometric *and* photometric calibration, which means that no additional user intervention is required to obtain the latter. We take advantage of the fact that our pattern effectively samples the space of surface normals to sample an irradiance map which we deconvolve to render virtual objects with correct specular reflections and cast shadows, such as those of Fig. 1(c) and 1(d).

To demonstrate our software effectiveness and ease of use, we distribute the code under a GPL license [1]. For more details, the interested reader can refer to our long paper at ISMAR06 [2].

Demonstration Description

The demonstration is a live presentation of our calibration system. Participants will have a chance to modify the camera setup, calibrate it and then play with a real-time augmented planar object. A simple textured box serves as calibration pattern. The demonstration shows very well how the light map is built and updated, with instantaneous effect on the augmented scene. The demonstration is made with a few cameras connected to a laptop. Here are the different parts of the demonstration:

- How to turn any planar object into a calibration pattern.
- The geometric and photometric calibration process itself.
- Real-time augmentation and light map update.

References

[1] CVLab Software. `http://cvlab.epfl.ch/software/`.

[2] J. Pilet, A. Geiger, P. Lagger, V. Lepetit, and P. Fua. An All-In-One Solution to Geometric and Photometric Calibration. In *International Symposium on Mixed and Augmented Reality*, Santa Barabara, CA, October 2006.

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