Proposal of Indoor Wide-Area Projection System using Multiple ProCam Units

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***Abstract*— To achieve multi-projection in an indoor space, it is necessary to measure the projection space, determine the position of each projector, and correct distortions caused by the projection surface. The construction of a multi-projection system is challenging to achieve easily, as it demands time and effort. In this study, we propose an easy multi-projection system using ProCam units for indoor spaces with unknown geometry.**

I. Introduction

Recently, multi-projection technology has been utilized in various exhibitions and events as a highly expressive spatial presentation. Multi-projection requires cancellation of geometric distortions caused by the shape of the projection and high-precision matching of overlapping projection areas to achieve seamless projection. To achieve these, Raskar et al. [1] proposed a method using stereo cameras, and Tehrani et al. [2] proposed an automated method for multi-projection construction using SfM method. However, these methods require projection onto a 3D shape whose projection surface is not flat, making it difficult to automatically construct a multi-projection using video projection onto a wall surface in indoor spaces with many flat surfaces. In this study, we propose a multi-projection system that can be automatically constructed in indoor spaces with unknown geometry by using calibrated integrated units, ProCam units of a projector and a camera.

II. Proposed Method

In this study, automatic calibration of multi-projection in an indoor space with unknown geometry is achieved by using ProCam units. The use of pre-calibrated ProCam units eliminates the need to calibrate the equipment, which could not be automated for flat surfaces due to dimensionality degeneracy and enables projection in indoor spaces with a mix of planar and 3D surfaces.

ProCam units consists of a common projector and camera, and are designed so that their fields of view overlap to enable measurement of the projection surfaces. In automatic calibration, the pre-calibrated ProCam units are placed onto the projection surface and the projection surface is measured. Gray codes and phase-shift codes are projected from a projector and captured by each unit's camera. The captured images are used for 3D reconstruction of projection surfaces, plane estimation, position and orientation estimation between units, and integration of the projection surfaces of each unit. The plane estimation separates planes from measured point clouds. In rendering, drawing combining the point cloud and the planes improves rendering speed and maintains geometric distortion correction accuracy. In addition, 2-Pass Rendering is performed using the measured projection plane to achieve geometric distortion correction from the user's viewpoint.

III. Results

Fig. 1 shows the rendering results of a measurement onto one plane with a projection distance of 1 m. Fig. 1(a) is before, and Fig. 1(b) is after the introduction of plane estimation. Fig. 1 (b) shows that the projection accuracy has improved.

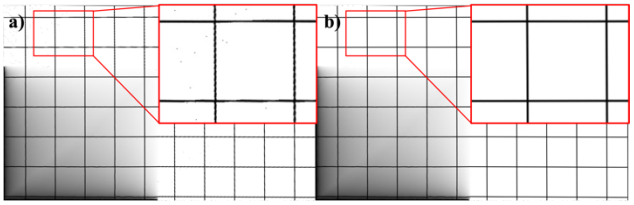

Figure 1. Rendering Results

Fig. 2 shows the projection results of the proposed method using two ProCam units. Fig. 2(a) shows the results of projection onto one plane at a projection distance of 1 m, and Fig. 2(b) shows the results of projection onto two planes at a projection distance of 1.75 m. The projections of the two projectors are seamlessly connected, and the geometric distortion caused by the wall corners is corrected. We confirmed that the proposed method can automatically calibrate in about 80 seconds, including code projection.

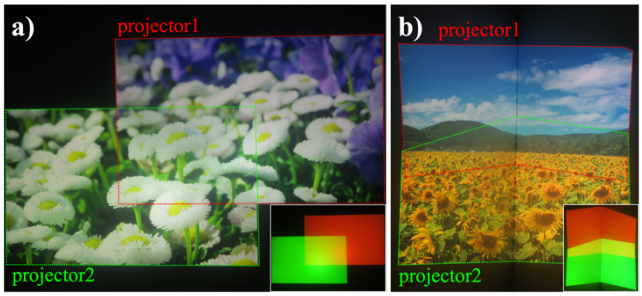

Figure 2. Projection Results

References

[1] R. Raskar et al., "Multi-projector displays using camera-based registration," Proceedings Visualization '99, 1999, pp. 161-522.

[2] M. A. Tehrani et al., "Automated Geometric Registration for Multi-Projector Displays on Arbitrary 3D Shapes Using Uncalibrated Devices," in IEEE Transactions on Visualization and Computer Graphics, vol. 27, no. 4, 2021, pp. 2265-2279.

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