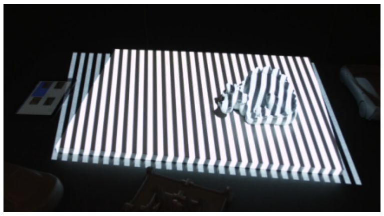
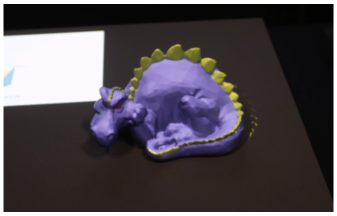
A method for automatically aligning projection mapping systems

Kevin Moule, Derek Scott, Nicholai Wasilka
Christie

Introduction

By creating an overlapped array of projected images, we can use projection technology to create truly seamless displays with resolutions that can scale up to tens of millions of pixels. Projection also lets us map these displays onto any surface, regardless of its shape or material.

A major obstacle to implementing these displays has been aligning and maintaining the display. There are commercially available automatic tools that configure and maintain projection systems on smooth, continuous surfaces (e.g. flat, cylindrical, spherical) but there are no tools that can align and maintain a display in a more complex projection mapping application without strong limitations placed on the system (and even that is assuming a simple canvas shape and correcting to the camera's perspective).

Christie's 3D Auto Alignment experiment

Our 3D Auto Alignment experiment is a prototype system that can rapidly and automatically align multiple projected images onto a surface of known geometry.

Using available digital models, such as the Phlegmatic Dragon[1], we constructed real-time content of the model using Touch Designer from Derivative Software[2] and printed a matching physical reproduction of the model using an iPro SLA system.

The experiment's goal was to construct a system that would automatically align the digital-model content onto the physical model when the physical model and a pair of projectors are placed in an arbitrary position and orientation within a scene. We achieved our goal without using physical sensors or optical fiducials.

Implementation

The system calibration is broken into two stages: configuration of the vision system followed by configuration of the display. The vision system is composed of two calibrated cameras (with intrinsic parameters pre-calculated), each with a view of the entire display area. The vision system is calibrated by placing a checkerboard of known dimensions in the view of both cameras.

SIGGRAPH 2015 Emerging Technologies, August 09 – 13, 2015, Los Angeles, CA.
ACM 978-1-4503-3635-2/15/08.
http://dx.doi.org/10.1145/2782782.2785590

The system uses the images of this known pattern to solve automatically for the extrinsic parameters (i.e. position and orientation) of each camera.

Once the vision system is calibrated, we can correct for any movement of the model and/or one or both projectors by running the projection alignment system. This process involves projecting a series of structured light patterns from each projector. The patterns are used by the vision system to create a 3D point cloud of data. This vision system uses this data to calculate the intrinsic and extrinsic characteristics of the projectors as well as the position and orientation of the model on the display surface.

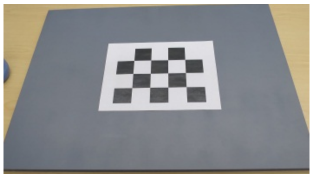


Figure 1: Calibration pattern

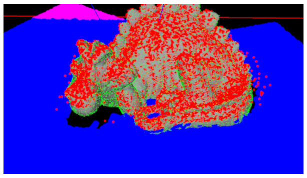


Figure 2: Geometry point cloud

With both the position of the model and projectors known, the model is then positioned correctly in the virtual environment where a viewport is created that matches the position and orientation of each of the projectors.

The whole process – from projecting the patterns to calculating the poses - takes about 15 seconds. We expect to be able to reduce this time to only a few seconds per projector.

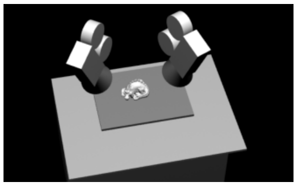


Figure 3: The calibrated virtual environment

References

"EG 2007 Phlegmatic Dragon" Eurographics 2007

Derivative Software https://www.derivative.ca/