Real Time Perspective Correction of Projector Image Using “Structure Sensor” Depth Camera

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Motivation

There are multiple existing methods for perspective correction of projector images, however, they traditionally require projecting a calibration image onto the object surface in order to learn the homography required to correctly prewarp the image. With the use of new infrared depth cameras, this calibration step can be foregone, and correction homographies can be calculated in real time. Although this project focused on perspective correction of projection onto flat surfaces, this project can be expanded in the future to account for correction of projection onto arbitrary surfaces as well.

Systems like this one can be used in applications where the projector must be casually placed in relation to the object screen, or in art pieces where the projector or object screen may be in motion.

References:
[1] Grossberg, Michael D., Harish Peri, Shree K. Nayar, and Peter N. Belhumeur. "Making one object look like another: Controlling appearance using a projector-camera system." In *Computer Vision and Pattern Recognition, 2004. CVPR 2004. Proceedings of the 2004 IEEE Computer Society Conference on*, vol. 1, pp. I-452. IEEE, 2004.
[2] Bimber, Oliver, Andreas Emmerling, and Thomas Klemmer. "Embedded entertainment with smart projectors." *Computer* 38, no. 1 (2005): 48-55.
[3] Yoo, Hyun Woo, et al. "Real-time plane detection based on depth map from kinect." *Robotics (ISR), 2013 44th International Symposium on*. IEEE, 2013.

Pipeline

- 320x240 depth image of sloped surface is collected from Structure Sensor which is placed at a measured transform in relation to the projector.
- Depth image is read into OpenFrameworks, a C++ 3D framework.
- Depth image is preprocessed.
- Normal of the projector screen is detected.
- Image to be projected is prewarped based on orientation of projector screen.
- Corrected image is projected onto the sloped surface, resulting in a rectangular projected image of correct aspect ratio when viewed normal to the object surface.

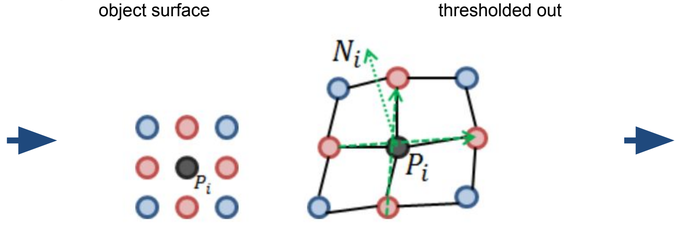
Correction Method

Depth image of scene without object surface

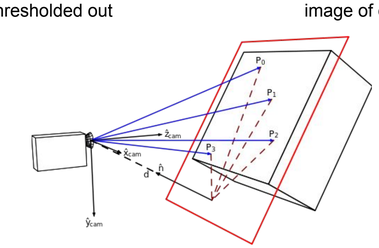
Back wall predicted and thresholded out

Scene floor predicted and thresholded out

Median filter on thresholded image of object surface



Local normals on object surface calculated and used to predict normal of entire surface



Object surface normal and projector FOV used to calculate proper prew

Experimental Results