**16-811 Math Fundamentals for Robotics, Fall 2015**

**Project Report**

**3D Scanning from Shadows**

Yi Hua, Mengxin Li

# Introduction

The technology, 3D scanning, is widely used, especially after the emergence of 3D printers. Current 3D scanners used in industry can be quite accurate, however, requires expensive hardware. Inspired by Jean-Yves Bouguet’s PhD thesis [1], we implemented a 3D scanner which makes use of the shadows of a stick onto the object that is to be scanned. Equipment required by this 3D scanner is quite simple: a camera, a stick, a lamp, a pencil and a chessboard. In this report, we will explain the method used to achieve the 3D scanning form shadows as well as present the results of the scanner. Analysis on the scanning results and potential improvements will be discussed in this report as well.

# Method and Intermediate Results

## An Overview of the Method

The general idea of the 3D scanner is illustrated in Fig.1. With a stick sweeping above the object to be scanned, there will be a line shadow of the stick projected onto the object and the table on which the object is put on. The camera will take a video of the object during the scanning process, therefore a sequence of frames of the object and the shadow can be obtained from the camera. By projecting the shadow line in the image to the 3D space and intersecting it with the horizontal plane, , we can obtain the shadow line, , in 3D space. Afterwards, the position of each point of the object in the 3D space can be obtained by intersecting the shadow plane defined by the light source and the shadow line, , with the line defined by the camera center, Oc, and the shadow pixel, p. Once having a dense estimation of the points on the object to be scanned, we are able to reconstruct the 3D shape of the object.

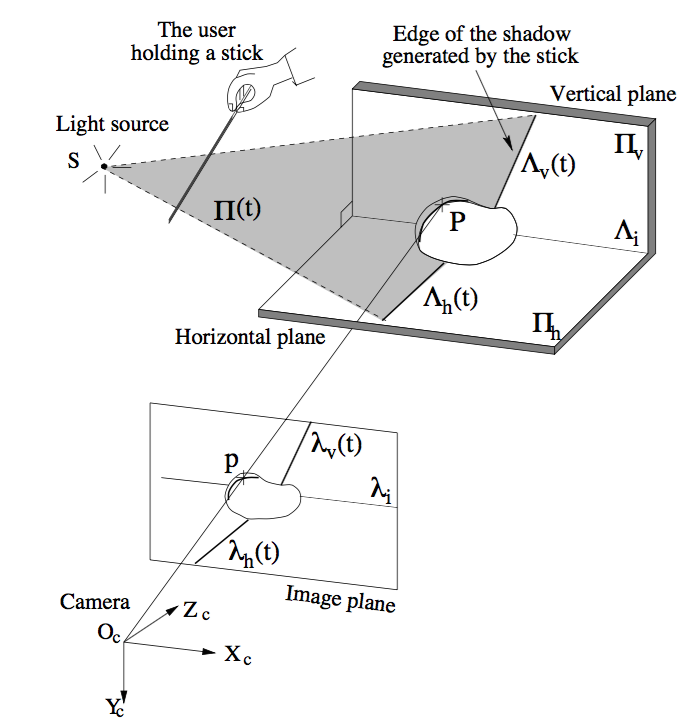


Fig.1 Method Overview

## Camera Calibration

The aim of camera calibration is to obtain the position of camera center and the camera intrinsic parameters (focal length, skew parameter, principal point and radial distortion factors).

## Light Source Calibration

## Shadow Edge Localization

## Shadow Plane Estimation

## Triangulation

# Overall Results and Analysis

# Conclusion

# Reference

[1] Jean-Yves Bouguet, 3D Photography on your desk, <http://www.vision.caltech.edu/bouguetj/ICCV98/index.html>

[2] Tsai R Y. A versatile camera calibration technique for high-accuracy 3D machine vision metrology using off-the-shelf TV cameras and lenses[J]. Robotics and Automation, IEEE Journal of, 1987, 3(4): 323-344.