High Accuracy Depth Measurement using Multi-view Stereo

Trina D. Russ and Anthony P. Reeves
School of Electrical Engineering
Cornell University
Ithaca, New York 14850
tdr3@cornell.edu

Abstract

A novel scheme for depth extraction is achieved using a multiple view ring camera system. The ring camera method captures a series of images of scene from a set of camera locations arranged in a circular ring. Tracking of scene features through this sequence realizes circular feature trajectories. The recovery of depth can be obtained with this method by determining the diameter of the circular trajectory. Depth obtained using the ring camera strategy is shown to be more accurate and more robust than binocular methods. In addition, associated with this method is a trajectory confidence measure which provides a good and reliable indication of depth accuracy.

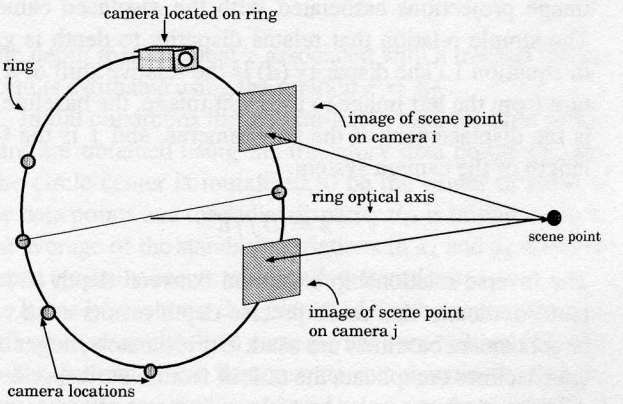

Figure 1: The Ring Camera Experimental Organization

1 Introduction

Depth maps from stereopsis methods that are both accurate and dense are difficult to achieve because of three fundamental problems associated with the depth extraction process: (a) feature correspondence, (b) occlusion, and (c) non-constant image brightness[3]. In this paper, we address the problem of accurate feature correspondence using a multiple baseline stereo system. The multiple baseline system allows the tracking of image features through a sequence of images captured at closely located positions, thus, enabling the use of moderate to large baselines without introducing additional ambiguity in the feature correspondence process. In addition, the utilization of multiple views typically provides a system which is more robust to image noise and less sensitive to occlusion.

In contrast to typical multiple baseline systems which simply displace a camera laterally [11, 13], we introduce the ring camera method for accurate depth measurement which acquires a sequence of images captured from locations arranged in a circular trajectory. Selected tracked features trace a circular trajectory whose diameter directly corresponds to binocular disparity. This work differs from previous research in multi-view depth measurement systems in two main characteristics: (a) the use of a geometric based confidence measure and (b) the large number of camera views used (more than 10). The geometric based confidence measure, based on multiple camera locations, is used to evaluate the confidence of the resulting depth measurement. Utilization of a large number of camera views permits robust accurate statistical depth measurement methods to be employed and increases the sensitivity of the confidence measure. Additional notable features of the ring camera method include the ability for anisotropic depth measurement, comparison of different feature types using depth confidence, and utilization of camera views placed along two dimensions.

For this system depth is reconstructed from a set of images without motion; obtained using either a moving camera and static scene or an array camera. In addition, we assume that the camera system has an optical axis that is orthogonal to the image plane and that the optical axis is fixed for all camera locations. The organization of the ring camera is shown in Figure 1. In this paper results are presented to demonstrate several advantages of this system which include: increased accuracy in comparison to binocular systems, increased robustness to image noise in comparison to a two view system, and a geometric based confidence measure which reliably determines depth uncertainty.