Calibration of a Wrist-mounted Range Profile Scanner

Colin Archibald
Shahram Amid †

Laboratory for Intelligent Systems
National Research Council of Canada
Ottawa, Ontario K1A 0R8

Abstract

The wrist-mounted range profile scanners developed in this laboratory provide depth information which is distorted due to the scanning mechanisms. Methods of removing the nonlinearities to provide an orthographic projection have been developed for other range finders, but for a variety of reasons, these have been found unsatisfactory for the large depth of view sensors. A new method and apparatus for calibration are described in this paper. Linear interpolation over multiple known samples of uncalibrated data are used to build a lookup table. The lookup table, stored in RAM, is accessed in realtime using the scanner hardware to provide calibrated data at a rate of 13 calibrated scans per second.

KEYWORDS: calibrate, 3-D, range finder, robot vision.

1. Introduction

The problem of calibrating 3-D laser range finders is an important issue in the application of sensor technology in the Laboratory for Intelligent Systems. A laser range finder that was specifically designed to be mounted on a robot wrist is described in [1]. This particular range finder was designed to have a large depth of field, and provides a single range profile. This is why it is referred to as a range profile scanner. The mechanical arrangement of the range profile scanner is shown in Fig. 1. Several methods have been used to transform the output from range finders to real world Euclidian space. [2][3] This paper deals specifically with calibrating the wrist-mounted laser range finder using linear interpolation.

The apparatus for collecting the raw data to be used in the calibration, and the procedure to do that collection, is nontrivial. These aspects of the calibration are theoretically not crucial to the calibration itself, but if not implemented in a user friendly manner will render the entire process cumbersome and unusable. The objective herein is to document the calibration method and describe the apparatus that has been developed. The system is documented in further detail in [4]. In section 2 the building of the calibration lookup table (LUT) using linear interpolation is described. The success of the calibration process can be measured by the ability of the range profile scanner to produce data in Cartesian coordinates that accurately depicts the surface being scanned. The accuracy of the scanner after calibration is discussed in section 3. Conclusions on the method described are found in section 4.

†Shahram Amid was an employee of McGill University at the time of this research.

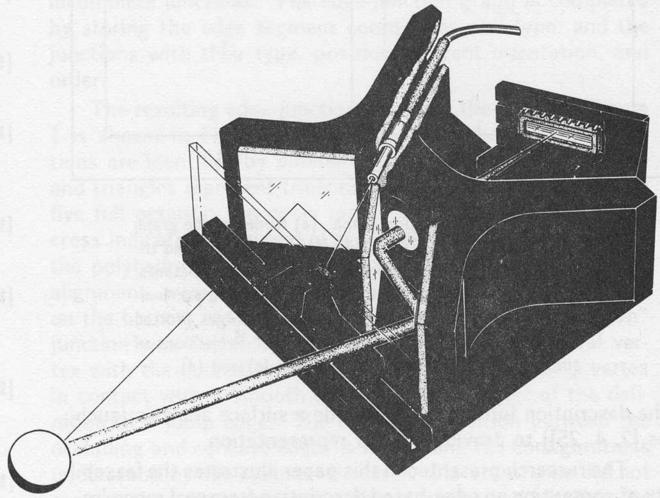

Figure 1. The mechanical arrangement of the wrist-mounted laser range finder to be calibrated.

2. Linear Interpolation for Calibration

The calibration process described here addresses problems of geometric and radiometric distortion related to optical and electrical components used in the range finder. [1]

The task is to couple the distorted polar coordinate system and the more useful Cartesian system by creating a lookup table. The lookup table contains Cartesian coordinate locations and is indexed by the raw range data, and the *azimuth* position. This azimuth position is simply the index, 1-255, of the scan drive system, which represents the angle of projection of the laser beam from the scanner. Interpolation is done between two adjacent scans of range values for each azimuth to obtain the Z values in the Cartesian coordinate system. These Z values are placed in the LUT. The X values for the X-Z coordinate pairs are computed using the Z values obtained from the table, and the linear equation of the azimuth in question. The method used to calculate the azimuth equations is described in section 2.2.

2.1 Advantages of Linear Interpolation

The calibration lookup table is affected by any degradation in the quality of raw data. There is some degradation in the raw data at the extremity of the scan due to