PROCESSING SINGLE RANGE PROFILES FROM A WRIST MOUNTED LASER RANGE FINDER

Colin Archibald

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

Abstract

Current robot vision systems consist of pseudo realtime feedback, where a scene is analysed while the robot is in a resting state, or otherwise occupied. For many applications a tight feedback loop with the robot servos being driven by sensor data is desirable. To this end, a lightweight, robot wrist mountable laser range finder has been developed at NRC. This sensor provides single scan lines of range data at a rate of approximately 13 calibrated profiles per second. Processing these scans to provide scene information is a unique problem and considerably different from intensity image processing, and should also be recognised as distinct from processing entire 3-D range images. Although there is only a single raster scan of data, explicit cues to the content of the 3-D scene are available. This paper describes a library of utilities written to extract information from the range profiles to be used in real time feedback control of the robot. Results of various operators, and combinations of operators, are presented. Potential applications and future directions are discussed.

KEYWORDS: robot vision, range data, laser range finder, profile interpretation, sparse range image.

1.Introduction

New sensors, and reasons for applying the sensors, are continually demanding innovative methods of extracting information about the real world from their signals. At NRC's Laboratory for Intelligent Systems we have taken the rather pragmatic approach of developing and applying sensors that provide a maximum of immediate, explicit 3-D information about the scene. The purpose of a laser range finder is to provide the location of a surface at many points, combined into a range image or a 3-D profile. A laser range profile scanner provides a single raster scan of surface information. The laser range finders developed here have been well documented elsewhere [1][2].

The surface information collected by the scanner is rarely perfect. In order to process imperfect data we need to understand the process by which it became imperfect. In intensity image processing this has been called the image formation process. Fortunately, there are only a few reasons why surface information may not be available from range data. For example, all light sensitive devices have a saturation point, and although the range finder returns depth, or range values, the electronics compute that measurement based on the position and amount of light reflected from the surface. Immediately, here are 2 reasons why no measurement would be available - too much, or too little light reflected from the scene. Secondly, the shadow effect phenomenon is inherent to triangulation based range finding technology [3]. The shadow effect occurs when either the projected laser or the sensor is occluded from a point which the other is not occluded from. For example, if the laser is illuminating a surface point, but that point is occluded from the sensor, no range data is available at this point. These aspects of the sensors capabilities leave gaps in the range data. The gaps are not merely errors in the data, it is known that no data is available at these points for one of the reasons mentioned above. It is then necessary to determine what should be placed in these gaps. Operators using large neighbourhoods, and global operators are not usefully applied to data with gaps. A typical method of filling gaps in range data has been to interpolate between the valid data points. This is acceptable for range finders with a short depth of field, but very detrimental to large depth of field range finders where it is possible to have shadow effects covering one third of the scan or more. Although the perspective distortion appears to be corrected in the calibration, there are some imperfections from a true orthographic projection, making the interpretation of the profiles slightly more challenging.

Once the gaps in the data are 'repaired', there are a variety of common operators that can be used to extract features from the range profiles. Several operators have been experimented with and current results are described in section 3. In section 2 the sensor is described briefly, along with the other apparatus used thus far. Conclusions, potential applications of this technology, and future research toward these applications are discussed in section 4.

2. Apparatus

The laser range finder that we are currently using is an instance of those described in detail in [5]. Some information specific to our device is included here. The sensor was designed specifically for large depth of field use, from 10cm to 1 meter, with best accuracy achieved at the shorter range. To date we have calibrated the device to return reliable data in the range of 11cm. to 70cm. measured from a reference point on the frame of the sensor. Fig. 1 shows the mechanical design of the range finder. A HeNe laser source arrives via an optical fiber. There are 3 fixed mirrors and one double facetted scanning mirror on the path of the laser from optical fiber to CCD. The double facetted mirror scans the scene driven by a galvanometer, over a 40 degree field of view. This means that the field of view is approximately 10 cm in the direction of the scan (we will call this the X direction) at a standoff of 10 cm (the Z direction). Where Z is 100 cm, the field of view is 80 cm in X.