GENERATION OF ORTHORECTIFIED RANGE IMAGES FOR ROBOTS USING MONOCULAR VISION AND LASER STRIPES

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***Abstract*— Range images have a key role for surface mapping in robot navigation and control. The robot control system can easily identify objects and obstacles by manipulating range images, however most of these range images are acquired in perspective projection, thus object position may be incorrect due to distortion caused by the perspective effect. This paper proposes an easy and efficient way to acquire range images, with a single CCD camera in conjunction with laser stripes and afterwards these range images are orthorectified to turn out to surface maps. These orthorectified range images are very useful for biped and quadruped robots, orientating them when navigating among obstacles while robot manipulators can use them to find objects by setting up their joints and picking tools.**

***Keywords*— rangefinder; robot control; vision system; laser stripes; orthorectification.**

I. INTRODUCTION

Range images are generally gray scale images whose pixel intensity represents elevation information of objects on a surface. A 3D surface reconstruction can be achieved if this surface has a range image.

This work proposes a computational, cost effective way to generate orthorectified range images compensating image perspective projection and radial lens distortion. Orthorectification aims to increase the precision especially for short distance images, where lens distortion and perspective effect are more visible.

In this paper, an active triangulation rangefinder has been developed using a monocular vision system composed by a CCD camera, calibrated for its intrinsic and extrinsic parameters and a laser, generating structured stripes on the surface for obtaining elevation information.

Bertozzi *et al.* (2000) described the pros and cons used for the detection of obstacles. He pointed out that stereo vision system is computationally complex, sensitive to vehicle movements and drifts and allows 3D reconstruction while optical flow, which is also computationally complex and sensitive to robot movements, demands a relative speed between robot and obstacles.

In this system, the computational time spent on generating the range images is lower if compared with stereo vision and optical flow techniques, thanks to the simplicity of the system modeling. This feature is fundamental for fast image processing serving the robot control system in a very satisfactory way.

There are several references for active triangulation laser rangefinders, some of them are mentioned here: Hattori and Sato (1995) proposed a high speed rangefinder system using spatial coded patters, Hiura *et al.* (1996) proposed a new method to track 3D motion of an object using range images, García and Lamela (1998) presented experimental results of a 3D vision system designed with a laser rangefinder, Haverinen and Röning (1999) presented a simple and low-cost 3D color-range scanner and Zheng and Kong (2004) introduced a method for calibration of linear structured light. For all these cited papers, there was no concern about the influence of image perspective effect on range images. This paper proposes an orthorectification process for correction of the perspective effect.

An application to the system is for a quadruped robot. The rangefinder has been assembled on Guará Robot (Bento Filho *et al.*, 2004), which has 4 legs and each leg with 4 degrees of freedom. Figure 1 shows the system installed in front of the robot so that while the robot walks, scanned images from the surface are acquired and processed to generate the orthorectified range images.

The full system description and modeling, camera calibration, radial distortion correction, projective transformation, orthorectification process and laser stripes calibration are described.

Experimental results have shown that the system has a very good performance becoming a powerful tool for robot navigation.

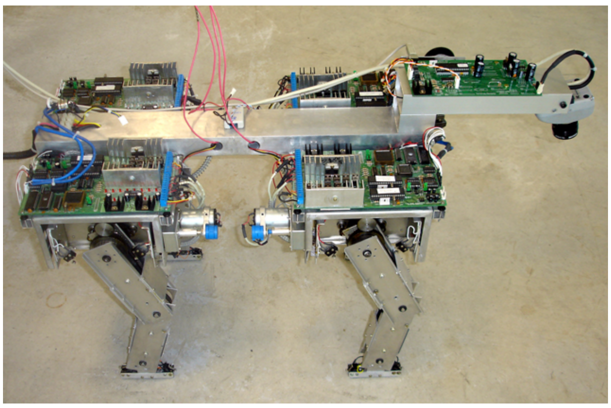

Figure 1: System assembled in front of Guará Robot.