Chapter 17
Intelligent Stereo Vision in Autonomous Robot Traversability Estimation

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ABSTRACT

Traversability estimation is the process of assessing whether a robot is able to move across a specific area. Autonomous robots need to have such an ability to automatically detect and avoid non-traversable areas and, thus, stereo vision is commonly used towards this end constituting a reliable solution under a variety of circumstances. This chapter discusses two different intelligent approaches to assess the traversability of the terrain in front of a stereo vision-equipped robot. First, an approach based on a fuzzy inference system is examined and then another approach is considered, which extracts geometrical descriptions of the scene depth distribution and uses a trained support vector machine (SVM) to assess the traversability. The two methods are presented and discussed in detail.

INTRODUCTION

Autonomous robots need to be able to operate in unknown, harsh environments and stereo vision can provide the means to cope with them in an efficient way. A basic but essential aspect of robots' autonomous operation is the assessment of terrain traversability, i.e. whether the robot is able to move towards a specific area or whether there are obstacles in front of it. Obstacle detection and traversability evaluation are important, as they provide crucial information for the safe navigation of mobile robots either for use in outdoor operations (Baudoin et al., 2009), or for use in space exploration, e.g. ESA's ExoMars rover (Kostavelis, Boukas, Nalpantidis, Gasteratos, &

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Figure 1. Robots equipped with potential stereo vision traversability estimation abilities

Aviles Rodrigalvarez, 2011), shown in Figure 1. However, the actual methodology to extract this kind of information in a resource-efficient manner is still an active and interesting research topic.

There is a plethora of non-vision sensors that are used by autonomous robots. Yet, stereo vision tends to be a favorable solution due to its versatile nature and its inherent biomimetic origin that have been proven to be of great reliability under a variety of circumstances. As a result, autonomous robots often use stereo vision as their primary source of information about the structure of the world around them. The requirements placed by robotic applications are very strict and, in general, different from the requirements usually adopted by the computer vision community. As such, special care has to be attributed to the characteristics of the vision system. However, solid stereo perception constitutes only the first step towards more advanced operations. When it comes for autonomous robots, the next big issue is terrain traversability estimation, and as a consequence obstacle avoidance. In this chapter two alternative approaches are discussed, both suitable for stereo vision equipped autonomous robots. More specifically, the first approach (Nalpantidis & Gasteratos, 2011) detects obstacles in the scene and avoids them based on a fuzzy inference system (FIS). 3D vision information is used by the algorithm to analyze depth maps and deduce the most appropriate direction for the robot to avoid any existing obstacles. On the other hand, the second approach considered (Kostavelis, Nalpantidis, & Gasteratos, 2011) uses a machine learning method based on a support vector machine (SVM) for the traversability classification of the terrain. A v-disparity image calculation and processing step extracts suitable features about the scene's characteristics. The resulting data are used as input for the training of the SVM. This approach is able to classify the scenes either as traversable or non-traversable with high success rates. The two approaches are different in essence and each one mainly focuses on different aspects, as it will be discussed.

BACKGROUND

Depth Estimation Using Stereo Vision

Stereo vision is often used in vision-based robotics, instead of monocular sensors, due to the simpler calculations involved in the depth estimation. A correspondence search between the two stereo images can provide dense information about the depth of the depicted scene. In the case of stereo vision-based navigation, the accuracy and the refresh rate of the computed disparity maps are the cornerstones of its success (Schreer, 1998). Dense local stereo correspondence methods calculate depth for almost every pixel of the scene, taking into consideration only a small neighborhood of pixels each time (Scharstein & Szeliski, 2002). On the other hand, global methods are significantly more accurate but at the same time more computationally demanding, as they account for the whole image (Torra & Criminisi, 2004). However, since the most important constraint in autonomous robotics is the real-time operation, such applications usually utilize local algorithms. Muhlmann et al. in (Muhlmann, Maier, Hesser, & Manner, 2002) describe a local method that uses the sum of absolute differences (SAD) correlation measure for RGB color images. Applying a left to right consistency check, the uniqueness constraint and a median filter, it can achieve 20