Identifying Vegetation from Laser Data in Structured Outdoor Environments

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Abstract

The ability to reliably detect vegetation is an important requirement for outdoor navigation with mobile robots as it enables the robot to navigate more efficiently and safely. In this paper, we present an approach to detect flat vegetation, such as grass, which cannot be identified using range measurements. This type of vegetation is typically found in structured outdoor environments such as parks or campus sites. Our approach classifies the terrain in the vicinity of the robot based on laser scans and makes use of the fact that plants exhibit specific reflection properties. It uses a support vector machine to learn a classifier for distinguishing vegetation from streets based on laser reflectivity, measured distance, and the incidence angle. In addition, it employs a vibration-based classifier to acquire training data in a self-supervised way and thus reduces manual work. Our approach has been evaluated extensively in real world experiments using several mobile robots. We furthermore evaluated it with different types of sensors and in the context of mapping, autonomous navigation, and exploration experiments. In addition, we compared it to an approach based on linear discriminant analysis. In our real world experiments, our approach yields a classification accuracy close to 100%.

Keywords: Vegetation detection, laser reflectivity, self-supervised learning, terrain classification, autonomous navigation

1. Introduction

Autonomous outdoor navigation is an active research field in robotics. In most outdoor navigation scenarios such as autonomous wheelchairs, surveillance robots, or transportation vehicles, the classification of terrain plays an important role as most robots have been designed to drive on streets and paved paths rather than on surfaces covered by grass or vegetation. Failing to stay on paved roads introduces the risk of getting stuck and additionally increases wheel slippage, which may lead to errors in the odometry. Therefore, the ability to robustly detect vegetation is important for safe navigation in any of the above-mentioned situations.

In this paper, we propose a novel laser-based terrain classification approach that is especially suited for detecting low vegetation. Such low vegetation typically occurs in structured outdoor environments such as parks or campus sites. Our approach classifies the terrain based on laser scans of the robot's surroundings in order to allow the robot to take the classification result into account during trajectory planning. Low vegetation poses a challenge for laser-based terrain classification since the variance in the measured distances is often small and thus it is hard to detect it from range measurements alone. Therefore, our approach exploits an effect that is well known from satellite image analysis: Chlorophyll, which is found in living plants, strongly reflects near-IR light [1]. Mobile robots are often equipped with laser range finders such as the popular SICK LMS scanners. These devices emit near-IR light and return the range to the object they measure along with the reflectivity of the surface. Our work formulates the detection of terrain as a classification problem that uses reflectivity, incidence angles, and the measured distances as inputs to identify whether a measured surface corresponds to vegetation. In addition to that, we provide a way to gather training data in a self-supervised way and thus eliminate the cumbersome work of manually labeling training examples.

In this work, we evaluate two sensor setups: rotating laser scanners capturing 3D pointclouds and laser scanners mounted at a fixed angle. We show that classifiers can be trained in a self-supervised way using a vibration-based classification approach to label training data. To integrate classification results into a representation of the environment, we apply a probabilistic mapping method similar to occupancy grid mapping [2].