

Article

On the Benefits of Color Information for Feature Matching in Outdoor Environments

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Abstract: The detection and description of features is one basic technique for many visual robot navigation systems in both indoor and outdoor environments. Matched features from two or more images are used to solve navigation problems, e.g., by establishing spatial relationships between different poses in which the robot captured the images. Feature detection and description is particularly challenging in outdoor environments, and widely used grayscale methods lead to high numbers of outliers. In this paper, we analyze the use of color information for keypoint detection and description. We consider grayscale and color-based detectors and descriptors, as well as combinations of them, and evaluate their matching performance. We demonstrate that the use of color information for feature detection and description markedly increases the matching performance.

Keywords: visual navigation; feature detectors; feature descriptors; feature matching; ransac; outdoor; color image processing

1. Introduction

Autonomous lawn-mowing under visual guidance is a complex task for outdoor robots. One of the basic elements is a visual navigation system that enables a systematic covering of the entire working area. In outdoor environments, varying illumination conditions as well as seasonal changes and nonplanar terrain pose multiple challenges to a visual navigation system. For the class of methods that we are interested in, the computation of the spatial relationship between arbitrary views (“home vectors”) is required. Therefore, we focus on feature matching without restricting the search space by feature tracking and study the effect of incorporation of color information in order to improve feature matching. Furthermore, we concentrate our study on the performance in the context of domestic gardens and lawns near public buildings.

Feature detection, description, and matching are fundamental parts of feature-based visual navigation. A wide variety of feature detectors and descriptors have been proposed in the last decades, for both grayscale and color images. A review and evaluation of different detectors and descriptors is beyond the scope of this article; we refer to [1] for grayscale images and [2] for color images. Most evaluations of different feature detectors and descriptors are found in the context of object recognition, image registration, camera calibration, and three-dimensional world reconstruction. Studies regarding the impact of different feature detectors and descriptors on the accuracy of visual simultaneous localization and mapping (vSLAM) are mainly restricted to indoor environments, grayscale features, negligible camera in-plane rotations, and short baselines between images [3–6].

In outdoor environments, autonomously navigating robots have to solve additional problems as compared to indoor environments. Incorporating color information is an obvious option to improve feature-based methods, as the main purpose of color descriptors is to increase the photometric invariance and the discriminative power. Previous studies on color descriptors have been limited to computer vision tasks, such as object and scene recognition, and they do not cover typical scenes