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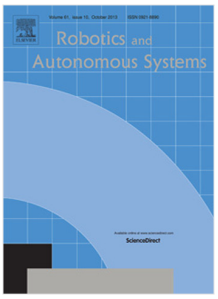

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Tomáš Krajník, Pablo Cristóforis, Keerthy Kusumam, Peer Neubert, Tom Duckett

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Image Features for Visual Teach-and-Repeat Navigation in Changing Environments

Tomáš Krajník[a], Pablo Cristóforis[b], Keerthy Kusumam[a], Peer Neubert[c], Tom Duckett[a]

[a]*Lincoln Centre for Autonomous Systems, University of Lincoln, UK*
[b]*Laboratory of Robotics and Embedded Systems, University of Buenos Aires, Argentina*
[c]*Dept. of Electrical Engineering and Information Technology, Technische Universität Chemnitz, Germany*

Abstract

We present an evaluation of standard image features in the context of long-term visual teach-and-repeat navigation of mobile robots, where the environment exhibits significant changes in appearance caused by seasonal weather variations and daily illumination changes. We argue that for long-term autonomous navigation, the viewpoint-, scale- and rotation- invariance of the standard feature extractors is less important than their robustness to the mid- and long-term environment appearance changes. Therefore, we focus our evaluation on the robustness of image registration to variable lighting and naturally-occurring seasonal changes. We combine detection and description components of different image extractors and evaluate their performance on five datasets collected by mobile vehicles in three different outdoor environments over the course of one year. Moreover, we propose a trainable feature descriptor based on a combination of evolutionary algorithms and Binary Robust Independent Elementary Features, which we call GRIEF (Generated BRIEF). In terms of robustness to seasonal changes, the most promising results were achieved by the SpG/CNN and the STAR/GRIEF feature, which was slightly less robust, but faster to calculate.

Keywords: visual navigation, mobile robotics, long-term autonomy

1. Introduction

Cameras are becoming a de-facto standard in sensory equipment for mobile robotic systems including field robots. While being affordable, small and light, they can provide high resolution data in real time and virtually unlimited measurement ranges. Moreover, they are passive and do not pose any interference problems even when deployed in the same environment in large numbers. Most importantly, the computational requirements of most machine vision techniques are no longer a significant issue due to the availability of powerful computational hardware. Hence, on-board cameras are often used as the primary sensors to gather information about the robot's surroundings.

Many visual robot navigation and visual SLAM methods rely on local image features [1] that allow to create quantitatively sparse, but information-rich image descriptions. These methods consist of a detection and a description step, which extract salient points from the captured images and describe the local neighborhood of the detected points. Local features are meant to be detected repeatedly in a sequence of images and matched using their descriptors, despite variations in the viewpoint or illumination. Regarding the quality of feature extractors, a key paper of Mikolajczyk and Schmid [2] introduced a methodology for evaluation of feature invariance to image scale, rotation, exposure and camera viewpoint changes. Mukherjee et al. [3] evaluated a wide range of image feature detectors and descriptors, confirming the superior performance of the SIFT algorithm [4]. Other comparisons were aimed at the quality of features for visual odometry [5] or visual Simultaneous Localization and Mapping (SLAM) [6]. Unlike the aforementioned works, we focus our evaluation on navigational aspects, especially to achieve long-term autonomy under seasonal changes.

Although the problem of long-term autonomy in changing environments has received considerable attention during the last few years [7], the main efforts were aimed at place recognition [8] and metric local-

Email addresses: tkrajnik@lincoln.ac.uk (Tomáš Krajník), pdecris@gmail.com (Pablo Cristóforis), kkusumam@lincoln.ac.uk (Keerthy Kusumam), peer.neubert@etit.tu-chemnitz.de (Peer Neubert), tduckett@lincoln.ac.uk (Tom Duckett)