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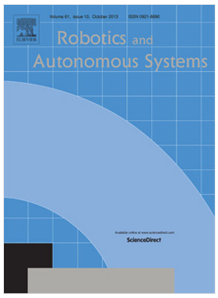

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Vision-based Markov Localization for Long-term Autonomy

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Abstract

Lifelong autonomous operation has gained much attention in the field of mobile robotics in recent years. In the context of robot navigation based on vision, lifelong applications include scenarios with substantial perceptual changes due to changes in season, illumination and weather. In this paper, we present an approach to localize a mobile robot, equipped with a low frequency camera, with respect to an image sequence recorded in a different season. Our approach employs a discrete Bayes filter with a sensor model based on whole image descriptors. We compute a similarity matrix over all image descriptors and leverage the sequential nature of typical image streams with a flexible transition scheme in the Bayes filter framework. Since we compute a probability distribution over the entire state space, our approach can handle complex trajectories that may include same season loop-closures as well as fragmented sub-sequences. Furthermore, we show that decorrelating the similarity matrix results in an improved localization performance. Through an extensive experimental evaluation on challenging datasets we demonstrate that our approach outperforms state-of-the-art techniques.

Keywords: Lifelong Visual Localization, Robot Vision, Long-term Autonomy, Perceptual Changes, Markov Localization

1. Introduction

The area of vision-based robot localization has achieved considerable progress in the past [1, 2, 3, 4, 5, 6, 7, 8]. However, long-term vision-based localization still is a challenging and unsolved problem. In principle, pure visual localization of a robot can be carried out with a monocular camera but changes in weather conditions, illumination variations, different seasons and times of the day make the task even more challenging. In this paper, we present a robust approach to localize a mobile robot equipped with monocular camera with respect to an image sequence recorded in a different season. Our approach employs a discrete Bayes filter with a sensor model based on whole image descriptors. We furthermore focus on handling complex trajectories, which include partially overlapping routes and multiple loops in a database sequence as well as in a query sequence. Additionally, our approach can deal with the typically large variety of perceptual changes. In our experimental evaluation we show that our method provides reliable location estimates and that it can handle a variety of different conditions.

As places undergo extreme appearance changes due to different weathers, times of day and seasons, we need an image description technique that is robust to all these variations and changes minimally. Keypoint-based image description has shown to be robust to various image deformations like scale, rotation and viewpoint change [9] but does not cope equally well with perceptual variations [10]. The keypoint-based description of an image for a par-

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