Chapter 33
Evaluation of Image Detection and Description Algorithms for Application in Monocular SLAM

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ABSTRACT

The results of new experiments on the detection and description of images for an EKF-SLAM monocular application are employed in order to obtain a dispersed set of features without related data association problems. By means of different detectors/descriptors, the number of features observed and the ability to observe the same feature in various captures is evaluated. To this end, a monocular vision system independent of the EKF-SLAM system is designed and implemented using the MatLab software. This new system allows for—in addition to image capture—the detection and description of features as well as the association of data between images, thus serving as a priori information to avoid incorrect associations between the obtained features and the map of an EKF-SLAM system. Additionally, it enables the evaluation and comparison of the precision, consistency and convergence of various algorithms.

INTRODUCTION

In the field of mobile robots, autonomy is one of the most important features that need further development to improve decision-making before unknown conditions of a medium. Therefore, describing the environment in which the robot is located and the relation of the robot with it becomes fundamental. Simultaneous Localization and Mapping (SLAM) techniques address this problem by gradually constructing a metric map and simultaneously localizing the robot in that map. Through obtaining both entities, it is possible for a robot to navigate in unknown and remote environments, being able to perform risky tasks sometimes impossible for a human being. Notwithstanding, research conducted is not pertinent to all types of applications; for instance, land mobile hexapod robots, that is, with three pairs of legs, have

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not been studied in depth. These robots are suitable for navigation in non-structured environments, i.e. without regular properties; thus, the study of SLAM applied to them would allow for exploring environments deemed unreachable for other robots.

Nowadays, different authors have proposed a large variety of SLAM algorithms, several of which are available in open code (Chen & Cheng, 2010) and accessible via MatLab software. Among the proposed systems, a predominant research field is SLAM based on artificial vision, specifically SLAM systems based on EKF applied to monocular vision or monocular EKF-SLAM. In this context, the implementation of Civera et al. (2010), which comprises the study of RANdom SAmple Consensus (RANSAC) to establish correspondence between distinctive features of an image, stands out.

In a monocular EKF-SLAM system, the information for detection of a feature is used to define in pixels the coordinates at which a point of interest, i.e. a point of the landmark 3D space, is projected on the image plane. Meanwhile, the information for the description of one feature is employed in the association of data between points of interest. Classically, detection is achieved by means of corner detectors such as Harris, Shi-Tomasi, and FAST[1]'s. Then, an 11x11-pixel image patch is saved from the first observation and projected on the image plane to search for and establish correspondence with features obtained in the captures of Davison (2003), and Davison et al. (2007). Although the classical combination between corner detectors and image patch descriptors is computationally one of the fastest, it lacks in precision (Gauglitz et al., 2011).

Considering the above, in this chapter we present results of new experiments in the detection and description of images with the purpose of improving the precision when obtaining visual features for an application of monocular EKF-SLAM, using MatLab as computational support. Firstly, new detection and description algorithms used in this platform are introduced. Secondly, the design and implementation of a program for the study and analysis of detectors and descriptors is detailed. Finally, the results of the tests conducted, along with the conclusions and projections of this work are presented.

RELATED WORK

At present, there is a wide range of algorithms for the detection and description of image features, therefore a comparative study of those algorithms becomes necessary to evaluate their behavior in a SLAM system. Although the comparative work of these technologies focuses on artificial vision applications, three important studies in the field of visual localization and SLAM should be noted. Firstly, the work of Gauglitz et al. (2011) presents an extensive analysis of the various combinations between detection and description algorithms for a visual localization application. Secondly, Gil et al. (2010) conduct a comparative study on detectors and descriptors for visual SLAM, which is based on the measurement of the repetition in which features appear in successive images (recall) and on the precision of the features obtained by the compared algorithms. However, despite the comparison being useful to improve the system's precision, this study does not consider the uncertainty inherent to SLAM. Finally, Klippenstein and Zhang's (2009) work proposes a new methodology that employs various detectors in order to evaluate the performance of a SLAM system by means of a test of accumulated consistency and uncertainty.

We now present an evaluation of various image detectors and descriptors using MatLab R2014a Computer Vision System Toolbox. A monocular vision system that allows generating a disperse map of visual features is introduced, thereby simplifying data association. Thus, the evaluation of the detectors and descriptors is performed based on the quality of the generated map. The detectors and descriptors