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Speeded Up Detection of Squared Fiducial Markers

Francisco J. Romero-Ramirez[1], Rafael Muñoz-Salinas[1,2,*], Rafael Medina-Carnicer[1,2,*]

Abstract

Squared planar markers have become a popular method for pose estimation in applications such as autonomous robots, unmanned vehicles or virtual trainers. The markers allow estimating the position of a monocular camera with minimal cost, high robustness, and speed. One only needs to create markers with a regular printer, place them in the desired environment so as to cover the working area, and then registering their location from a set of images.

Nevertheless, marker detection is a time-consuming process, especially as the image dimensions grows. Modern cameras are able to acquire high resolutions images, but fiducial marker systems are not adapted in terms of computing speed. This paper proposes a multi-scale strategy for speeding up marker detection in video sequences by wisely selecting the most appropriate scale for detection, identification and corner estimation. The experiments conducted show that the proposed approach outperforms the state-of-the-art methods without sacrificing accuracy or robustness. Our method is up to 40 times faster than the state-of-the-art method, achieving over 1000 fps in 4K images without any parallelization.

Keywords: Fiducial Markers, Marker Mapping, SLAM.

1. Introduction

Pose estimation is a common task for many applications such as autonomous robots [1, 2, 3], unmanned vehicles [4, 5, 6, 7, 8] and virtual assistants [9, 10, 11, 12], among other.

Cameras are cheap sensors that can be effectively used for this task. In the ideal case, natural features such as keypoints or texture [13, 14, 15, 16] are be employed to create a map of the environment. Although some of the traditional problems of previous methods for this task have been solved in the last few years, other problems remain. For instance, they are subject to filter stability issues or significant computational requirements.

In any case, artificial landmarks are a popular approach for camera pose estimation. Square fiducial markers, comprised by an external squared black border and an internal identification code, are especially attractive because the camera pose can be estimated from the four corners of a single marker [17, 18, 19, 20]. The recent work of [21] is a step forward the use of this type of markers in large-scale problems. One only need to print the set of markers with a regular printer, place them in the area under which the camera must move, and take a set of pictures of the markers. The pictures are then analyzed and the three-dimensional marker locations automatically obtained. Afterward, a single image spotting a marker is enough to estimate the camera pose.

Despite the recent advances, marker detection can be a time-consuming process. Considering that the systems requiring localization have in many cases limited resources, such as mobile phones or aerial vehicles, the computational effort of localization should be kept to a minimum. The computing time employed in marker detection is a function of the image size employed: the larger the images, the slower the process. On the other hand, high-resolution images are preferable since markers can be detected, even if far from the camera, with high accuracy. The continuous reduction in the cost of the cameras, along with the increase of their resolution, makes necessary to develop methods able to reliably detect the markers in high-resolution images.

The main contribution of this paper is a novel method for detecting square fiducial markers in video sequences. The proposed method relies on the idea that markers can be detected in smaller versions of the image, and employs a multi-scale approach to speed up computation while maintaining the precision and accuracy. In addition, the system is able to dynamically adapt its parameters in order

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