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AFFINE-INVARIANT GRAPH MATCHING FOR TEXTURE-SCARCE IMAGES VIEWED FROM DIFFERENT DIRECTIONS IN LUNAR ROVER LOCALIZATION

Abstract

In the Lunar Exploration, one important mission of the ground teleoperation center is estimating the position of each navigation station that the rover reaches, which facilitates the rover to gradually approach and finally get to the scientific probing targets. Vision-based localization is usually considered as the most perspective method, since it takes a very good balance of precision, accessibility and reliability. It has been successfully used in Lunar and Mars rovers, such as Yutu, Spirit, Opportunity and Curiosity, and will be further developed in Exo Mars and CE-4 Lunar rovers. Despite of these applications, there are still some problems difficult to solve, mainly include three aspects: first, the appearances and the colors of locally acquired lunar or mars images are very similar, second, images acquired places for the rover have a fairly large position difference, which makes large scale difference between images to be matched, and third, rotational transformation and different illumination conditions always affect the appearance of images and features. These cause the point feature ambiguity, making the appearance-based local descriptors, like SIFT, less discriminative. Traditional appearance matching algorithms often failed in handling the above situations. Some improved appearance matching algorithms, which take the affine transformation of images into account, such as affine SIFT, perform better than traditional ones in handling large-scale transformation problem, but they are still not able to obtain satisfactory results in tackling the above situations. By utilizing the structural cues between points, in this paper, we propose an affine-invariant graph matching method to tackle the point correspondence problem in lunar surface images. In the graph matching, we consider not only the surrounding appearance, but also the structure relations of neighbor points to describe each feature point, which makes the matching more robust with respect to geometric transformations and illumination changes. In order to make the match more reliable, we utilize the approximate positioning information of the rover to project the images acquired from different positions to the same view, which greatly improve the efficiency of graph matching. To validate the proposed method, we conduct experiments with lunar surface images acquired by Chang'E-3 rover, and make detailed comparison on the performances of appearance-based matching method and structure-based graph matching method.