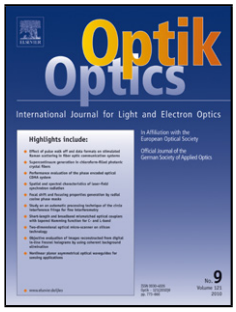

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Multiple circle recognition and pose estimation for aerospace application

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Abstract A novel recognition of ellipses and relative pose estimation algorithm is presented based on surface of revolution (SOR) in this paper for images of multiple ellipses. Firstly, the contours following method is performed on image to detect ellipses. Secondly, candidate ellipses projected by circular cross section of a SOR are obtained based on parallel constraint and vertical constraint in the image. Finally, relative pose between target and camera is calculated by these candidate ellipses. Experimental results indicate that the method perform well in recognition and estimation. The precision of recognition is higher than 97% for synthetic images corrupted by 0~16% salt-and-pepper noise. The absolute error of pose angle is 1°,and the absolute error in axis z and other axis are less than 80mm and 15mm, respectively, when measure distance is less than 10m.

Keywords machine vision; recognition of ellipses; Aerospace Applications; Monocular vision

1 Introduction

Circular objects are frequently seen in real world, especially for spacecraft such as docking ring component, rocket nozzle, cross-section of space station. Numerous scholars have attached importance to location and attitude estimation by computer vision techniques based on circles[1-6]. Intrinsically, circular targets offer arguably interesting visual clues: they can be easily detected and fitted, even if partially occluded. A circle or an ellipse in 3D space is projected to an ellipse in an image. Safaee[7] propose a location and attitude estimation method based on cone which is formed by camera center and ellipse in the image, but two possible pose solutions are obtained for this monocular vision method[8-16]. Zheng[10][11] develop the projective equation of a circle, and present a geometric explanation for the ambiguity of solutions, i.e., the ambiguity in identifying the image of circular points. Kim[12] and Jiang[13] propose that the image of circular points can be identified uniquely by image of concentric circle, and give the closed-form solution. Two parallel circle is used by wu[14] to determine the unique solution while three non-concentric circles are utilized by chen[15].

The above methods require ellipses which are used to built target coordinate system in the image to be easily identified from others. However, there may be multiple circles and some extraneous ellipses generated by noise, shadow or viewing angle in the image as shown in Fig.1. Therefore, the first step is to obtained the candidate ellipses which are used to built target coordinate system. Generally, there is a typical structure called surface of revolution (SOR) for most spacecraft such as docking ring component, rocket nozzle or space station. Circular cross section of a SOR satisfy that their supporting planes are parallel and the line passing all their centers is perpendicular to their supporting planes. Therefore a novel recognition algorithm based on parallelism and orthogonality constraint is presented to obtain candidate ellipses projected by circular cross section in the image, then a relative pose estimation algorithm is proposed for multiple ellipses. Consequently, in this paper we firstly detected ellipses in the image. Then, a randonm-based recognition algorithm is performed to obtained candidate ellipses. Finally, we estimate location and attitude between target object and camera based on candidate ellipses.