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Chinese Astronomy and Astrophysics 40 (2016) 277–290

CHINESE
ASTRONOMY
AND ASTROPHYSICS

A Star Pattern Recognition Method Based on Decreasing Redundancy Matching† ⋆

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Abstract During the optical observation of space objects, it is difficult to enable the background stars to get matched when the telescope pointing error and tracking error are significant. Based on the idea of decreasing redundancy matching, an effective recognition method for background stars is proposed in this paper. The simulative images under different conditions and the observed images are used to verify the proposed method. The experimental results show that the proposed method has raised the rate of recognition and reduced the time consumption, it can be used to match star patterns accurately and rapidly.

Key words techniques: image processing—telescopes—methods: statistical

1. INTRODUCTION

In the observation of space objects, the astronomical positioning method can provide an observed object with high-accuracy equatorial coordinates. An important procedure of astronomical positioning is to calculate the plate model by using the calibration stars, in which first of all the matching problem of calibration stars should be solved. The matching of calibration stars indicates to find out the stars corresponding to the star images in the actually observed image from the star catalogue, after matching, using the catalogue equatorial coordinates (α_i, δ_i) of multiple calibration stars, and the equatorial coordinates (A, D) of the telescope pointing, according to the formula of gnomonic projection, we can obtain the ideal

† Supported by National Natural Science Foundation (11273069, 11403108)

Received 2014–12–12; revised version 2015–02–11

⋆ A translation of *Acta Astron. Sin.* Vol. 56, No. 4, pp. 399–409, 2015

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doi:10.1016/j.chinastron.2016.05.010

coordinates (ξ_i, η_i) and the measured coordinates (x_i, y_i) of calibration stars , then, to derive the relation of conversion from measured coordinates to ideal coordinates, namely the plate constants[1].

The manufacturing and assembly errors of the telescope mount, optical system, encoder and CCD device cause the static pointing error[2,3], and the rapid motion of the telescope mechanical equipment causes the dynamic pointing error[4], in addition to the measuring error of centroid position of the star image itself, all these factors make the measured coordinates of star images approximate to, but not coincident with their ideal coordinates. When the differences between the measured coordinates and the ideal coordinates are not significant, the calibration stars can be accurately matched by using the neighborhood matching method[5,6]. However, when significant pointing error and tracking error exist, the neighborhood matching method will be invalid, in this case we need a matching method which does not depend on the prerequisite condition that the measured coordinates are close to the ideal coordinates. This paper adopts a mode matching method, in which as the translation and rotation invariants, the angular distances of star pairs among the calibration stars are taken as the basic matching elements, which can solve the problem of accurately matching the star pattern under the condition that the measured coordinates have a rather large translation and rotation relative to the ideal coordinates.

The mode matching method has been widely used in the field of star pattern recognition of star sensors[7]. One kind of these methods establish a simple geometrical configuration to make mode matching based on the star-pair angular distance, for example, the triangle algorithm[8,9], the pyramid algorithm[10], etc.; another kind of methods take the selected principal star as the matching element, and take the distribution feature of the stars around the principal star as the matching mode, and finally that of highest similarity is selected as the matching result, for example, the grid algorithm[11,12], the radial/annular distribution feature recognition algorithm[13], etc.

The mode matching method has been successfully used for the calibration of astrometrical images, for example, in Reference [14], by the quadrilateral star configuration the 4-dimensional vector which reflects the relative positions of 4 stars is produced, and used as a matching mode with the invariance of translation, rotation, and proportion. Besides, Reference [15] proposed also to use the ratios of triangle areas in the quadrilateral star configuration to be the mode vector. These methods have produced a huge mode database, hence a rapid search is realized by using the kd-tree method, and finally the result is output after eliminating the redundant matching by through a verification process. The above methods are purposed specially for calibrating astrometrical images, the mode database is relatively large, and the verification process is time consuming, unfavorable to the real-time processing of images, hence they can hardly be applied to the star pattern matching in space object observations.

When the mode matching is performed on the whole sky area, the more simple the