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Object Recognition Method of Space Debris Tracking Image Sequence† ⋆

ZHANG Chen[1,2] PING Yi-ding[1,3]

[1] *Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008*

[2] *University of Chinese Academy of Sciences, Beijing 100049*

[3] *Key Laboratory of Space Object and Debris Observation, Chinese Academy of Sciences, Nanjing 210008*

Abstract In order to strengthen the capability of space debris detection, the automated optical observation becomes more and more popular. Thus, the fully unattended automatic object recognition is urgently needed to study. As the open-loop tracking, which guides the telescope only with the historical orbital elements, is a simple and robust way to track space debris, based on the analysis on the point distribution characteristics of object's open-loop tracking image sequence in the pixel space, this paper has proposed to use the cluster identification method for the automatic space debris recognition, and made a comparison on the three kinds of different algorithms.

Key words astrometry—techniques: image processing—telescopes—methods: data analysis

1. INTRODUCTION

The optical observation of space debris is characterized by the objects' rapid motion on the star background, which is the major difference from the ordinary astronomical observation. In order to raise the measuring precision and depth, in the observation the telescope should keep tracking the observed object.

In the light of implement methods, the debris tracking can be divided into two modes: close loop tracking and open-loop tracking. In close-loop tracking, the motion of the tele-

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△ zhangchen@pmo.ac.cn

△△ ydping@pmo.ac.cn

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scope is regulated in real time according to the actually observed data in this very period of tracking. In the early stage of debris observations, because of the relatively low prediction precision at that time, the observation needed manual attendance, and the close-loop mode played an important role. In addition, in some important observational missions or at the time to observe a newly discovered object, in order to prolong as possible the observational arc, this mode plays an indispensable role. But the close-loop tracking program is complex in implementation, with a high requirement on the reality of time, it needs plenty of manual attendance. In the existing automatic unmanned observational procedures, there exists often the problem that the tracking course is not robust.

In the open-loop tracking, the motion of the telescope is guided only by the predicted data during the whole tracking course. The prediction accuracy of the debris now catalogued is sufficient to support the open-loop tracking[1−2]. As compared with the close-loop tracking, the open-loop tracking has a stronger ability to resist disturbance, favorable for realizing robust tracking, and providing the observational data with more stable quality, because of the separation of telescope motion control from the image data treatment in its implementation. In the meticulous study of known objets, the effect of this tracking mode may be brought into full play.

The key difference between the close-loop tracking and the open-loop tracking lies in that in the observation of close-loop tracking, the object recognition either has been implemented by the observer, or is implemented by the observational program in real time—the problem of non-robust tracking in the observation is exactly caused by this very procedure; while the object recognition in the observation of open loop tracking can be carried out in the latter process of data treatment. In order to accommodate to the current large-scale observation and research of space debris, it is necessary to automatize this procedure as far as possible. This is just the aim of our work.

As for the existing methods of automatic recognition of observational images of space debris, no matter the real-time treatment or the post treatment, all the main methods take tracking as the prerequisite, and use the orbit information[3−4], point-angle feature[5], edge feature[6] to match images, and to analyze the relation and difference between the front and latter frames of images, then to judge the object position and to fit its trajectory. This manner requires either a very accurate initial value, or a large number of iterative calculations to delete false alarms; and in the recognition of a single frame of image only the information of a few front and latter images is utilized, which results in a low reliability of recognition and being liable to be disturbed. In this paper, the features of data sequence in open loop tracking observation are analyzed, the cluster identification method based on the characteristics of point distribution on a long arc is put forward to implement the automatic object recognition, and to meet the needs of extensive space debris sampling.