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A Research on the Orbit Determination Method by Means of Sparse Data of Electronic Fences*

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Abstract Based on the Lambert equation and knowledge of space geometry a method of orbit determination is given using the sparse observational data provided by the space monitoring electronic fence device. Our simulated experiment of a large number of targets shows that the initial orbit determined by this method can be improved and can converge to a final accuracy better than 100 m, so proving that the method can be applied to the orbit determination of an overwhelming majority of space targets with the observed data of the electronic fence. Finally, the effect of the latitude of the observing station on the application of the method is discussed.

Key words: instrumentation: miscellaneous—celestial mechanics: orbit determination

1. INTRODUCTION

The US NAVSPASUR Electronic Fence, which is still being used up to this day since its completion and commissioning into active service in 1961, is the longest-serving and most productive among the space target monitoring facilities. The statistics show that the US electronic fence can record 60000 explorations every day and can make more than a million observations per month. Most of the observational targets are the low earth orbit satellites, among which there are at least more than one hundred satellites of which routine explorations can be carried out only by making use of the electronic fence, and the number of the targets

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which can be monitored by the electronic fence amounts to 70 per cent of the total number of catalogued targets of the US space monitoring network[1].

However, there have been no public reports on the mechanism of applying the sparse observational data of the electronic fence to orbit determination. In this paper we propose such a method together with a current recognition and understanding of the electronic fence space exploration in China in the hope that it will play an active role in the deepening of the theory and understanding of space monitoring in China.

2. CHARACTERISTICS OF THE DATA AND ANALYSIS OF THE FEASIBILITY OF ORBIT DETERMINATION

Initial orbit determination in the traditional sense, i.e., in the sense of the two-body problem, generally requires that the observational data does not cover more than 1/4 of the circle. The measurement information obtained by the electronic fence is in the form of extremely short segmental arcs covered when the space target passes through the beam thickness of the electronic fence, reduced after the processing to a single space position vector, plus information on whether the passage is ascending or descending. When the target passes through the fence beam twice in succession in the same direction (both are the ascending or descending passages), the difference between the two obtained positional vectors differ by almost a complete circle; when the target passes the fence beam successively in different directions (one ascending and one descending), the time interval between the two obtained position vectors is generally a few hours. Thus, the observational data of the electronic fence are so sparse that the traditional method of calculating the initial orbit is improper. And if the target passes through the fence many times in the same sense (all ascending or all descending), the position vectors will be concentrated to within an extremely small segmental arc, creating a serious morbid state for the orbit determination.

However, since the electronic fence is not distributed in the equatorial or the two polar regions, the distance between the two groups of data from ascending and descending branches can not be too close together in the orbital plane, nor in completely opposite directions. Therefore, the orbital plane can be approximately determined by simultaneously using observations of the ascending and descending branches. Meanwhile, the nodical period can be estimated from the time difference between two consecutive passages of the same node, hence an estimate of the orbital semi-major axis a. Given a, the dynamic relation among the observed data of passages of the same sense is characterized by the Lambert equation (the influence of perturbation can be neglected within the short time involved), from which the initial orbit of the target is determined. From this we have developed in this paper the basic idea of using the observed data at two ascensions and one descension (or two descensions and one ascension) to determine the initial orbit. A large volume of calculations have shown that the initial orbit so determined can guarantee the convergence of the orbital improvement, thereby verifying the effectiveness of this method in forming a whole set of methods for determining the target orbit using the sparse observational data of the electronic fence.