Orbit determination in large datasets

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Abstract. In this talk, we present a new procedure to explore large datasets of unlinked detections. This procedure is based on a first exploration of the data using a Keplerian Integrals method that allows us to link two tracklets even when they are separated in time by a few years. In the second step, we represent the results obtained with a graph where the tracklets are the nodes and the preliminary orbits are the edges. Then, we identify the valid 3-cycles and for each of them we compute a least squares orbit. Finally, we try to construct sequences of $n \geq 4$ tracklets identifying the orbits of the 3-cycles that are close enough and trying the attribution of the remaining tracklets. This procedure offers good results and can be used efficiently in non static datasets such as the Isolated Tracklet File of the Minor Planet Center.

Keywords: Orbit determination · Linkage Problem · Asteroid surveys.

1 Motivation

Over the last years a large number of improvements in the observational techniques have been implemented, allowing to collect a huge number of asteroid detections every night. Moreover, the forthcoming surveys, e.g. the VRO-LSST [1], are going to further increase the amount of collected data.

All these observations are grouped in very short arcs (VSA), also called tracklets, each referring to the same observed object. The information contained in a VSA is usually not sufficient to compute a reliable least squares orbit and in this case, they are stored in the isolated tracklet file (ITF), available at the Minor Planet Center database [2].

The ITF is an ever changing list of unlinked tracklets of more than 9 million of observations mainly provided by Pan-STARRS1 [3] and Catalina [4]. In the current version of the ITF these two observatories provide more than 4 and more than 2 million observations, respectively.

For this reason, our goal has been to develop a procedure that not only allows a complete and deep exploration of large databases, but also can adapt to the successive changes that appear in the data.

2 The procedure

The procedure we have created can be described with the following steps:

First, we try to link all the possible pairs of tracklets using a linkage method introduced in [5]. This method, that we call `Link2`, is based on the conservation laws of Kepler's problem, and enable the linkage of very short arcs of optical observations even when they are separated in time by a few years. The low computational cost of this algorithm and its numerical behaviour (see [6]) make it suitable for this purpose.

In order to join more than two tracklets we note that the results obtained with `Link2` can be expressed as a graph $G = G(V, E)$ where the set of vertices $V = \{1, 2, ..., N\}$ corresponds to the set of tracklets, and the set of edges E corresponds to the linkages found. Using this graph representation, we construct 3-cycles, composed by 3 tracklets such that each pair of them has been successfully linked in the previous step. For each 3-cycle we compute a norm, taking into account all the orbits obtained by `Link2` with the 3 possible pairs of tracklets, and keep only the 3-cycles with a value of this norm below a suitable threshold. Then, for each accepted 3-cycle, we compute a least squares orbit together with its rms.

Finally, we try to construct least squares orbits with $n \geq 4$ tracklets identifying the orbits of the 3-cycles that are close enough and trying the attribution of the remaining tracklets. In our procedure we assume that the information contained in 4 tracklets is enough, in general, to build a robust orbit.

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