Identification of Known SSO in CU4 Object Processing

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Introduction

The identification of known solar system objects (SSO) that will be observed by Gaia is a key point of the solar system object processing pipeline (CU4.SSO). It aims to associate the provisional tag assigned to observations of probably solar system objects to already known targets. At the time Gaia flies, it can be estimated that about 600,000 solar system objects (mainly small solar system objects) will be known and characterized by an orbit accurate enough to make their identification almost certain.

1. Context of the identification process

SSO, as well as non-single stars and extended objects, cannot be processed by the same pipeline than the stellar objects, mainly because:

- SSO have a proper motion and need a dedicated astrometric solution
- SSO can be extended objects and need a dedicated photometric analysis
- SSO are not observed at the same place at each transit so that we need to link up observations

After being processed by CU3/IDT, a source is either successfully matched to an existing stellar object (i.e. all celestial object which is not SSO) or remains unmatched. In that case, a second processing is performed by CU4/SSO/DU452 to try to identify the source as a known SSO and to assign it an identifier, at the level of short-time processing (1 day), and at the level of long-term processing (6 months). In both cases, the success or not of the identification process decides which treatment is applied or not to the analyzed transit.

2. Identification method

2.1 The problem

The main problem to cross-match sources with SSO in astronomical images resides in the apparent motion and the relatively high number of SSO. The first point implies that the ephemeris of all known objects have to be accurately computed at the epoch of the image to be able to cross-match the sources. The second point implies that we must reckon on a rather long computing time: if we need 1 millisecond to compute the ephemeris of one SSO, then this will take more than 540 seconds (more than 540000 SSO are known at that time) to identify only one source! This is not possible when thousands of sources have to be processed daily.

2.1 A solution

Being moving objects, the cross-matching of an observed source with a known SSO requires to compute the ephemeris of each of them at the time of observation because we don't know *a priori* where they are located in the solar system. To solve this issue, we adopted the solution to compute in advance the ephemerides of all the known SSO at tabulated epochs, and to store them in a dedicated database. The identification process is then reduced to a simple conesearch method, supplemented by the computation of accurate ephemeris of a limited set of bodies.

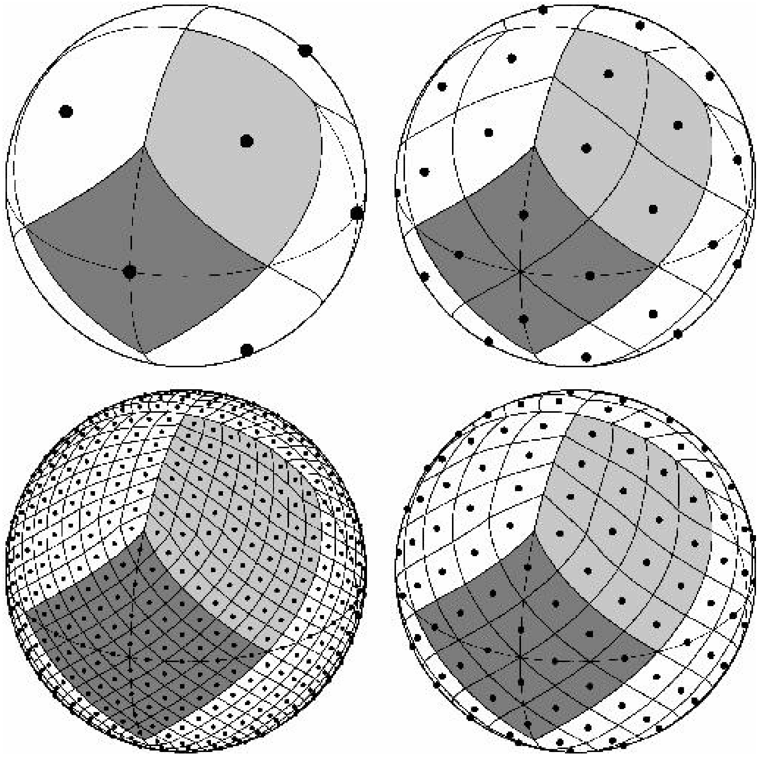

Fig. 1 – Healpix cutting of the celestial sphere

On the base of our experience with such problem (Berthier et al., 2006), we have chosen to use the mathematical structure of Healpix (Górski et al., 2005) to store the tabulated positions in function of time of all known SSO. The sphere is hierarchically tessellated into curvilinear quadrilaterals, with the lowest resolution partition comprised of 12 base pixels. The resolution of the tessellation is then increased by division of each pixel into four new ones. The figure 1 illustrates (clockwise from upper-left to bottom-left) the resolution increase by three steps from the base level (i.e. the sphere is partitioned, respectively, into 12, 48, 192, and 768 pixels). The properties of Healpix implies that areas of all pixels at a given resolution are identical, and that pixels are distributed on lines of constant latitude.

These properties of Healpix makes it very efficient to store the coordinates of SSO because it supports a suitable discretization of functions on a sphere to different levels of resolution, so that it facilitates fast and accurate statistical analysis. We have chosen to use a grid resolution of k = 9 (Nside = 512), so that the sphere is cut in 3145728 pixels of angular size 6.87 arcmin.That ensures us that only very few SSO may be selected at once before cross-matching, and thus that ensures a short computing time.

Conclusion

This work is still in progress, and we don't have numbers to quantify the success and the accuracy of the identification process. But to ensure a high level of success, we know that we need high accuracy orbital elements. That means that, at the time Gaia will fly, we will need complementary astrometric observations of i) unmatched sources in order to confirm or not that it is a SSO, and ii) ambiguous cross-match to improve the accuracy of orbital elements and then, perhaps, properly identify the SSO.

References

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