

SkyBoT, a New VO Service to Identify Solar System Objects

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Abstract. The Institut de mécanique céleste et de calcul des éphémérides (IMCCE, Paris Observatory) provides to the Astronomical Virtual Observatory a new service of identification and ephemeris computation dedicated to the solar system objects. This service, named SkyBoT¹ is fully VO compliant and provides solar system objects ephemeris in VOTable format through web service facilities.

1. Introduction

During the last decades, the volume of data produced by the numerous astronomical facilities (terrestrial or space telescopes, space probes, etc.) has expanded greatly. As a consequence, the volume of data available to astronomers grows proportionally so that more and more insights into astronomy and astrophysics can come from combining information obtained by different techniques at many wavelengths. However, the data are not easily combined because the datasets are numerous and come from different people that using different methods and techniques. The Virtual Observatory provides an answer to this issue by building bridges between the archives that allow to share data and to interoperate.

It is in this context that the Institut de mécanique céleste et de calcul des éphémérides (IMCCE) has the ambition to place at the disposal of the Virtual Observatory its knowledge and its expertise on the dynamics and the physics of the solar system bodies. Among the various VO projects of the IMCCE, one service has been developed especially for the VO in collaboration with the Centre

¹<http://skybot.imcce.fr/>

de Données Astronomiques de Strasbourg (CDS). This service, named SkyBoT, is the first VO service that provide data about the solar system objects.

2. SkyBoT's Concept

SkyBoT (Sky Body Tracker) is a XML web service, VO compliant, which provides quick identification and ephemeris of the solar system objects in any astronomical field of view at a given epoch.

The core of the service is a MySQL database of pre-computed ephemeris of all of the known solar system objects (asteroids, planets, natural satellites and comets) over the period 1949-2019. The service is accessible through HTTP query form and SOAP web service on the IMCCE's web site (see Berthier 2005). A php/MySQL engine is used to extract the data and to interpolate the ephemeris. The tabulated ephemeris saved in the database are :

- J2000 mean geocentric equatorial spherical coordinates which are used as starting point to interpolate the ephemeris for a given epoch
- J2000 mean heliocentric equatorial rectangular coordinates which are used as initial conditions for further computation (numerical integration for example)

The ephemeris provided by the web service are J2000 astrometric geocentric equatorial coordinates. They are computed by fitting an orbital arc of 10 days using rational fraction polynomial method. The orbits are computed by numerical integration of the 9 bodies perturbed problem (including the post-newtonian approximation) with a sampling step of 1 day. The dynamical properties of the asteroids come from the ASTORB database (see Bowell 2005). The SkyBoT database is updated weekly on the basis of the ASTORB database downloaded through VizieR service (see Ochsenbein 2000).

The SkyBoT database is composed of two kinds of tables: some of them store the 10 days tabulated ephemeris of all the objects and the others store the region of the sky crossed by the objects over a period of 10 days (cf. Figure 1). In order to determine where the objects are located in function of time, we have cutted out the celestial sphere in boxes of about 20x20 arcmin. This cut-out has been chosen to insure an equilibrium between the data storage and the kind of requests. We have considered that common requests may concern field of view of 1 degree more or less, so that just few boxes are queried each time. This structure of the database allows a response going from few seconds (field of view lesser than 1 degree) to less than 5 minutes for a 20 degrees field of view. The number of objects that are retrieved spreads out from few tens to few thousands respectively. The parameters which determine the structure of the database will be improved in the future as soon as a significant sample of requests will allow us to better foresee the need of users.

The accuracy of the ephemeris provided by SkyBoT are at the level of 10 milli-arcseconds to tens or hundreds or thousands of arcseconds depending on the quality of the orbit (defined by the absolute value of the current 1- σ ephemeris uncertainty parameter of Astorb). As the accuracy of orbits depends on the

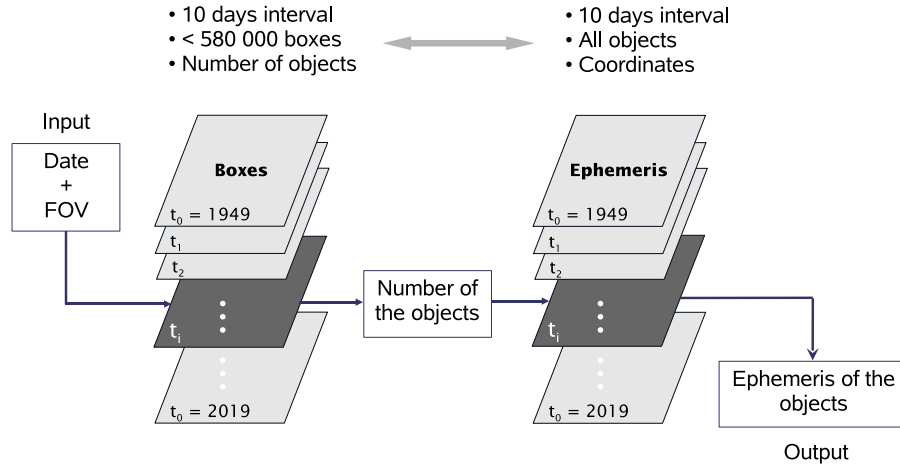


Figure 1. Structure of the SkyBoT database

number and the orbital arc spanned by the observations that are fitted, it may occur huge errors on the position of some asteroids. It will fall within the competence of the user to filter the objects before using their ephemeris.

3. SkyBoT's Tools

The SkyBoT service can be used as cone-search or resolver tool. In the first case, it allows to retrieve and identify all the known solar system objects located in a time-stamped field of view. In the second case, it allows quick ephemeris computation of any solar system objects at a given date so that, for example, the designation of a solar system object can be very quickly resolved into celestial coordinates. Informations and help about how to consume the SkyBoT's web service are available on the IMCCE's web server (see Berthier 2005).

The service has also been implemented by CDS in the Aladin Sky Atlas software (see Bonnarel 2000) as a dedicated overlay. It allows users to explore any time-stamped astronomical digitalized image and to superimpose, identify and retrieve the location of known solar system objects present in the image. Different kind of filters (on the magnitude, error position, proper motion, etc.) allow one to embed the outputs. The orbital data for each object are also available through the VizieR detailed page as well as on-line ephemeris computation through the IMCCE's ephemeris web server.

4. Science Cases

SkyBoT is a powerful tool to make science. It is useful to make real-time search and identification of minor planets. It can be helpful for data mining of astronomical observations of solar system objects. It can be useful to simulate data to prepare space missions (Gaia, interplanetary navigation, ...) and to visualize the 3D structure of the solar system. It is also helpful to improve the orbits of asteroids such as Near Earth Asteroids by recovering pre-discovery astrometric positions in the various astronomical surveys. This science case is one of the next important step in the IMCCE's VO roadmap.

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