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Exploring the solar system with Mega-Precovery data mining server: strengthening our database and functionalities

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Abstract. Mega-Precovery is an online service focused on data mining few collections of instruments archives, with the aim to improve the orbital and physical knowledge of known asteroids and other Solar System objects. Mega-Precovery comprises a collection of millions of images which can be searched for serendipitous recoveries and *precoveries* (apparitions before discoveries). In this work we present a data mining of ESO WFI and INT WFC archives and some precoveries using this tool, developed within the European Near Earth Asteroid Research project (EURONEAR), in collaboration with the IMCCE Observatoire de Paris.

Resumen. Mega-Precovery es un servicio online enfocado en data mining de algunas colecciones de archivos de instrumentos, con el propósito de mejorar el conocimiento orbital y físico de asteroides conocidos y otros objetos del Sistema Solar. Mega-Precovery contiene una colección de millones de imágenes en que pueden buscarse recuperaciones casuales y *precoveries* (apariciones antes de descubrimientos). En este trabajo presentamos un data mining de archivos del ESO WFI e INT WFC y algunos precoveries usando esta herramienta, desarrollada en el contexto del proyecto European Near Earth Asteroid Research, en colaboración con el IMCCE Observatoire de Paris.

1. Introduction

Mega-Precovery is an online service focused on data mining few collections of instruments archives, with the aim to improve the orbital and physical knowledge of known asteroids and other Solar System objects. This paper is a detailed description of this online service aiming to enhance the search capabilities of important objects, such as Potentially Hazardous Asteroids (PHAs), Virtual Impactors (VIs) or newly discovered objects. Mega-Precovery is dedicated to

search among large collections of archives, using a big database able to scan among different instrument archives, speeding up data mining of asteroids in a flexible way, where the user even can add his/her own instrument archive. A sample of these capabilities is shown in this work, mining the ESO WFI and INT WFC archives during a decade sky coverage.

2. Data mining with Mega-Precovery

Mega-Precovery was developed in the frame of the EURONEAR project with the main science goal to ameliorate the NEA orbits and improve their ephemerides. It follows its precursor Precovery software and allows querying all catalogued asteroids (including all known NEAs and PHAs) and comets, looking for potential encounters of one or few object to report a candidate recovery or precovery (recovery before discovery date). Recoveries could enlarge the observed arcs, firm orbits by adding second-opposition data, ameliorate orbits and minimal orbital intersection distance with Earth (MOID). Mega-Precovery includes three huge archive collections in its database (the Mega-Archive): ESO (15 instruments), NVO (8 instruments) and CADC (11 instruments, including HST), and other important archives (CFHTLS, INT/WFC, Subaru/SuprimeCam, AAT-WFI, SDSS), totaling 39 instruments and 4.3 million images. New archives and up-to-day new searching capability functions are under development.

3. Mining the ESO WFI and INT WFC archives

This mining effort comprises ESO Wide Field Imager (WFI) and INT Wide Field Camera (WFC) archives. The WFI, mounted in the 2.2m ESO/MPG telescope in La Silla Observatory (Chile), was scanned during the period 25-10-1999 (first light) to 27-08-2009 (start of this project); the WFC, mounted in the 2.5m Isaac Newton Telescope (INT) in Observatorio Roque de los Muchachos, Canary Islands (Spain), was scanned during the period 20-06-1998 (first light) to 10-07-2009 (start of this project). The sky coverage of both projects is portrayed in Figure 1.

As published in Vaduvescu et al. (2013), the sky coverage of both hemispheres from La Silla (Chile) and ORM (Canary Islands) was appropriate for asteroid detection, as seen in Figure 1. In total, 152 objects were measured and reported in a team including students and amateurs: 44 PHAs and 108 other NEAs; 18 precoveries and 10 recoveries were achieved. The astrometry was performed using the Astrometrica software (Raab 2012) to resolve the astrometry of the fields. The asteroids are searched (and its positions measured) in the candidate images by blinking the previously aligned images of the same field. Finally, the astrometry is checked by possible errors (e.g. faint objects affected by bright stars, larger sky uncertainties, bad identification, etc.) using the FITSBLINK asteroid residual server calculator (Skvarc 2012) or the EURONEAR O-C calculator. Once this process is completed, the datasets are reported to the Minor Planet Center. The datasets for the ESO WFI and INT WFC archives included 316 positions of 55 objects found in the ESO archive and 445 positions for 97 objects found in the INT archive, in total 152 objects and 761 measurements.

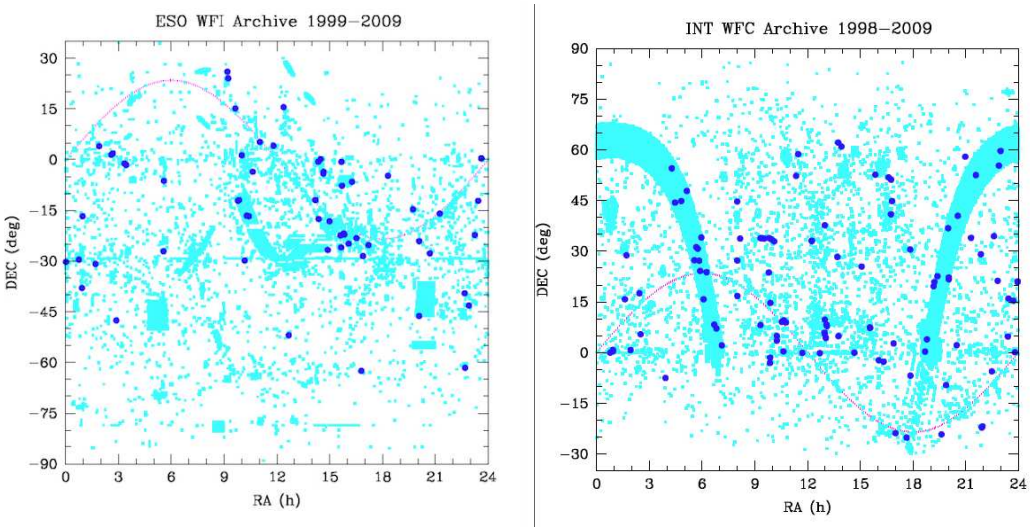

Figure 1. Sky coverage of the archives from ESO WFI (left) and INT WFC (right). The observed fields are marked as cyan (fainter) dots. Blue dots are the NEAs and PHAs encountered. Ecliptic is marked in magenta (Vaduvescu et al. 2013).

4. Mega-Precovery software

To retrieve the logs of images for a desired object, the Mega-Precovery tool (written in PHP) queries the selected archives extracted from the current observing logs (CCD imaging archives), as seen in the provided flowchart (Figure 2). The output is a list containing the candidate images holding the given search asteroid (NEA, PHA, MBA or other Solar System bodies (comets, MBCs, etc.), and soon to be extended to other Solar System bodies; the result is displayed both via web interface and sent by email. The user can download the images for a further analysis of the desired asteroid. The ephemeris calculation is done through the Miriade server developed by J. Berthier et al. at IMCCE (Berthier, 2009). Few recent examples of precoveries using Mega-Precovery in SuprimeCam and SDSS archives include the NEAs 2012 RX16 (3 month arc extended to 8 years; MPEC 2013-Y11, Vaduvescu & Hudin 2013), 2007 TK15 (one month arc precovered 1.5 years), 2011 GM44 (one month arc prolonged to 5 years), the PHA 2012 KC6 (2 month arc to 4 years), 2012 HC34 (6 month arc extended back to 10 years), 2009 UE2 (5 month arc extended to 2 years) and 2011KW19 (2 month arc precovered to 7 years), etc. (all to be published soon).

5. Conclusions

The Mega-Precovery software is presented as a new and improved data mining service (similar to the North-American Skymorph and SDSS), allowing to explore large datasets and search for serendipitous encounters of known NEAs and PHAs. For this data mining study involving ESO WFI and INT WFC, and using its precursor software, Precovery, an important number of NEAs were

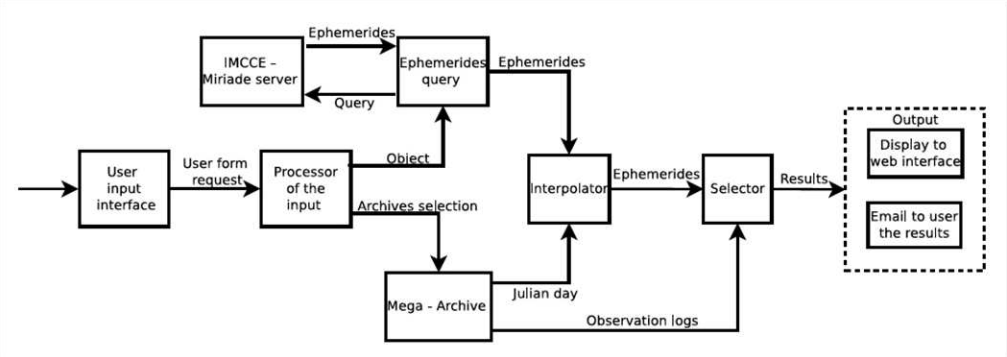

Figure 2. Flowchart of Mega-Precovery (Vaduvescu et al. 2013).

identified and measured, and their astrometry reported to the Minor Planet Center (MPC). The current Mega-Precovery tool will continue this effort focusing on data mining of many instrument archives, while many different capabilities are being added to its database: Mega-Archive will include ING (all imaging cameras), new search tools (query by orbital element or by observational arc) and new Solar System objects, such as bolides, planet satellites, etc. (we added comets recently), extending our mining capabilities. Currently, there are two main projects to be added: one is just to add new search options, and also to write some code in order to automatically and daily update the major archives (at least those served by major 3 archive servers).

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