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NEO Characterization

Enabling Small Body Precovery Searches in Any Astronomical Dataset

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ABSTRACT

The Asteroid Discovery, Analysis, and Mapping (ADAM) platform is a scalable cloud-based astrodynamics platform being developed by the Asteroid Institute, a program of the B612 Foundation. ADAM offers a variety of astrodynamics services and standardized astronomical datasets that, together, enable compute-intensive research in planetary science and planetary defense. Newly added to the suite of tools and services is ADAM::precovery. ADAM::precovery performs at-scale searches for as-yet unattributed observations of known asteroids from point-source catalogs. The goal of precovery is to find additional observations of known asteroids that aid in reducing the orbital uncertainty. The precovery service relies on mapping datasets from different observatories to a generalized and dataset-agnostic grid of exposures. Once mapped to this search efficient format, datasets can be simultaneously searched for point-source detections that may belong to a known asteroid. In the cases where a detection could have occurred but no point source was found, information about the image with which the asteroid's trajectory intersects is returned. Retrieving such images enables a deeper search when the object appears just below the detection threshold. Conversely, in the event of a complete non-detection, such images enable "negative observation" campaigns. In addition to returning point-sources that may match a given asteroid's orbit, ADAM::precovery offers additional visual validation by producing a mosaic of postage stamps along the trajectory of the moving object. ADAM::precovery can be used to search the NOIRLab Source Catalog, S-PLUS, and SkyMapper. Work is ongoing to enable searches in Pan-STARRS, ZTF, SDSS, and the Minor Planet Center's Isolated Tracklet File. Critically, our dataset selection is not limited to NEO-specific surveys – any astronomical dataset regardless of cadence is a dataset that may be used for discovery and precovery in the planetary defense context. The precovery service is publically available at https://adam.b612.ai/#/precovery.

We demonstrate the utility of such searches by finding precovery observations of three NEOs from the NASA and ESA impact risk lists: 2013 CY, 2015 EO, and 2018 RB_2. In each case, additional observations were found hidden in the NOIRLab

Source Catalog. Observations identified by ADAM::precovery were used to identify the locations of candidate trails for each object in images. These trails were then measured and submitted to the Minor Planet Center. After submission the orbital uncertainties decreased and the resulting impact probability of all three NEOs changed: slightly increasing for both 2013 CY and 2015 EO and decreasing for 2018 RB_2. We stress that this is only an initial demonstration of the capabilities of the ADAM::precovery service and we are now working on automating precovery searches for all risk list NEOs across all datasets maintained in ADAM.

Finally, we discuss plans to prepare for the volume and scale of the Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST). LSST is predicted to quadruple the known population of NEOs. Enabling precovery searches of LSST discoveries across multiple datasets will be important for additional characterization and orbit refinement for those NEOs which may pose an impact risk.

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Comments:

We would prefer an Oral presentation, if possible. Thank you!