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NEAT: The Next Generation

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Abstract

The Near-Earth Asteroid Tracking (NEAT) survey discovered 41,227 minor planets [3, 5], and reported observations of 258 comets. It operated from 1995 to 2007. It pioneered techniques used by major asteroid surveys today, along with Spacewatch [6].

Although NEAT was highly successful, it operated within the technological constraints of its time. In the intervening years, computer hardware and data analysis tools have advanced significantly. We harness this new technology to reprocess these images.

We expect our reprocessing of the NEAT data to increase NEAT near-Earth Object (NEO) detections by >150%. The reprocessing will produce accurate photometric measurements of NEOs, giving a long baseline of these observations, as well as observations over different time scales (minutes, hours, days, weeks). This will allow for the production of asteroid phase curves and the characterization of comet activity. New detections of known objects will, in many cases, extend observational arcs by decades. This allows for significant orbit refinement, which is of particular importance for potentially hazardous objects, and may allow for measurements of the Yarkovsky effect [4, 2].

1 The NEAT Survey

NEAT was a project of NASA's Jet Propulsion Laboratory and the Air Force Space Command. It began surveying in 1995, from Haleakala, Maui, HI, with the telescope being accessed remotely from Pasadena, California. Data was transferred using a modem and a 1-800 telephone number with an effective transmission rate of 1.5 kbps. In 2001, a second location became operational: Palomar Observatory in Southern California. NEAT used several 1-meter class telescopes, all with CCD cameras and large fields of view.

Throughout the program, NEAT employed a single observing cadence, imaging a location on the sky three times over $15-30$ minute intervals. These three images were called "triplets," and were analyzed for moving objects. Follow-up observations of new discoveries were also conducted. The survey generally covered more than six thousand square degrees each month, avoiding the galactic plane, and prioritizing opposition. Weather permitting, NEAT operated in a series of six-night runs. An example search pattern from [5] is shown in Figure 1. Areas of the sky imaged during the first night were again imaged on the sixth night so that slow moving objects could be detected.

2 Benefits of Reprocessing

Current technology enables many improvements in data processing. Dynamic source extraction software can determine the background of the image and divide non-background portions of the image into separate

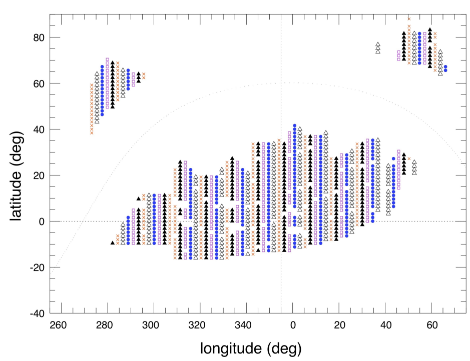

Figure 1: Example six night NEAT cadence, based on [5]. Orange 'x' marks are regions to be searched on the first and sixth night. White triangles, blue circles, purple squares, and black triangles show regions to be searched on nights 2, 3, 4, and 5, respectively. The Galactic plane is indicated via a dotted line, this region is avoided due to high source density. Smaller gaps are areas observed by Spacewatch, and are also avoided by NEAT.

objects, and is not limited by fixed-size ratios used by NEAT's STARCAT algorithm. STARCAT defined a feature that had 2x1 contiguous pixels all higher than 3 sigma. However, the software package Source Extractor can extract fainter sources that have a smooth point-source function brightness profile but only a single pixel higher than 3 sigma, for example.

Calibration was not always uniformly applied, and some nights lacked key calibration frames, like flats [1]. However, the NEAT PDS dataset provides appropriate calibration frames for most nights of observations, ready to be applied to the data. This in and of itself will improve the sensitivity, and provide a more stable sensitivity floor across the image frames between nights of observation.

Modern detection-linking software can explore a much larger parameter space than was possible with NEAT's algorithm, and can use orbit-fitting software to account for objects with non-linear sky motion (such as NEOs that are very close to Earth).

3 Status

We have begun the reprocessing of the NEAT dataset. Five Olin College undergraduates have begun writing an image processing pipeline that calibrates the images and identifies the sources using Source Extractor. Three students will continue this project full time in Summer 2019. They will refine the pipeline, add a machine learning component to classify sources, and begin work on modern detection-linking software.

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