NEW METHOD FOR IDENTIFYING ASTEROIDS OVER APPARITIONS AMONG A WEALTH OF SCARCE ASTROMETRY. Mikael Granvik[1,2] and Karri Muinonen[2], [1]Institute for Astronomy, University of Hawaii (2680 Woodlawn Drive, Honolulu, HI 96822, U.S.A., email: mikael.granvik@iki.fi), [2]Observatory, University of Helsinki (P.O. Box 14, 00014 Helsinki, Finland).

Introduction: Some 15% of the approximately 400,000 asteroids discovered so far are lost, which means that their orbital uncertainties are too large to allow straightforward recovery attempts. Typically the observational data for the lost asteroids spans only a few nights, but for distant objects the timespan can be even months. Although it would be extremely time consuming to search for the lost asteroids by covering large patches of the sky, there is another way to bring them back to the group of known asteroids. By using novel numerical methods to find observation sets that belong to the same asteroid among the scarce observation sets, the orbital uncertainty can be reduced to the point where obtaining follow-up or recovery observations becomes a viable option. Linkages are typically sought by comparing orbital elements that have been computed from different sets of astrometry. Due to the observational uncertainties and often long time intervals between the sets—say, several years—it is important to model the orbital uncertainties properly to allow a large fraction of the correct linkages to be detected. The work by A. Milani and his collaborators [1,2] has indeed shown that the number of linkages detected increases when the orbital uncertainties are modeled more accurately. So far most of the linkages found have been detected with Gaussian or partially-Gaussian methods [1,2]. We have recently developed a fully non-Gaussian method [3,4] based on statistical orbital ranging (Ranging; [5,6]), which should be able to detect linkages that have been missed by the earlier methods, either due to too scarce data or due to long linking intervals.

Numerical Methods: The new identification method can be divided into two main filters: the orbital-element multiple-address-comparison (oMAC) filter, and the orbital-verification filter. The oMAC filter essentially compares the extents of the sampled orbital-element probability densities to find overlapping sets of orbital elements. The optimal set of orbital elements found to date are the semi-major axis, eccentricity, inclination, longitude of the ascending node, argument of perihelion, and the time of passing the ascending node. Note that for scarce data, the uncertainty of the inclination is typically relatively small compared to the uncertainties of the other elements, and the ascending-node time is hence better defined than, e.g., the time of perihelion. For efficient comparison, we use tree-like data structures and dimensionality-reduction techniques [7]. If overlapping sets of elements are found, there is reason to assume that the corresponding observation sets may belong to the same underlying asteroid. The purpose of the second main filter is to verify that an orbit, which simultaneously reproduces the combined data set, actually exists. If an orbit is found and it reproduces the data accurately enough, we call it a linkage. Note that we do not yet have methods to assess the correctness of the linkages found.

Note that the techniques used in the oMAC filter allows it to be used also in connection with other types of sampling methods such as the Volume-of-Variation method [8] or methods developed by other groups.

Results: The new identification method has been successfully tested with synthetic near-Earth-object (NEO) and main-belt-object (MBO) data, which was generated using the ASurv software [3,7] with a cadence of three observations each separated by one hour on two consequtive nights during each apparition. The total timespan of the simulation was some 15 years. For MBOs, the sensitivity—that is, the fraction of correct linkages found—of the new method is higher than 95%, whereas for NEOs the sensitivity is somewhat lower but still higher than 90%. To the best of our knowledge, there does not exist other methods capable of linking such scarce astrometry over long time intervals and therefore we cannot compare the results.

Application to real data. The new identification method is currently being applied to all the approximately 35,000 designated sets of asteroid astrometry spanning more than 12 hours but less than 48 hours, and having been obtained between 1 Jan 1990 and 31 Dec 2006. Results will be presented during the meeting.

References: [1] Milani et al. (2000) *Icarus, 144*, 39–53. [2] Milani et al. (2005) *A&A, 431*, 729–746. [3] Granvik M. and Muinonen K. (2008) *Icarus*, in press. [4] Granvik M. (2007) PhD thesis, Department of Astronomy, University of Helsinki. [5] Virtanen J. et al. (2001) *Icarus, 155*, 1151–1154. [6] Muinonen et al. (2001) *CeMDA, 81*, 93–101. [7] Granvik M. and Muinonen K. (2005) *Icarus, 154*, 24–123. [8] Muinonen et al. (2006) *MNRAS, 368*, 809–818.

Additional Information: See also abstract entitled "OpenOrb: Open-Source Asteroid-Orbit-Computation Software Including Statistical Orbital Ranging."