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Development of an Intelligent Target Prioritization System for NEOCam Ground-based Follow-up

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ABSTRACT

NEO target prioritization is an important problem in planetary science. This is mostly due to the limited available ground observational resources which creates challenges for persistently and continuously observing all possible detected NEOs. Moreover, higher-level data products that are employed to gain knowledge of the observed NEOs (e.g. spectra, light curves, trajectories and rotational states) are generally uncertain due to instrument resolution and modeling errors. In addition to those challenges, the increasingly larger data volumes acquired by the deployed assets may not be suitable for continuous human-based processing where scientists have the burden of rapidly integrating a large amount of data in order to make decisions

on which NEOs to prioritize for further observations. Rapid response is essential because NEOs are often brightest at the epoch of their discovery and can become faint very quickly for long periods of time, complicating efforts to further characterize them.

Over the past few years, Artificial Intelligence (AI) methodologies have been developed that can efficiently and effectively mimic human thinking and can autonomously provide real-time inference from collected data. The latter generally result in Decision Support Systems (DSS) that can autonomously process data, infer critical parameters, make decisions and provide explanation of the system's conclusions. Here, we present the development and testing of a DSS for ground-based NEO target ranking and follow up. The overall goal was to design and test a cognitive system for autonomous and intelligent NEO target ranking that could be used to decide how best to obtain additional characterization data (such as spectroscopy, radar, or densely sampled lightcurves) for targets discovered by advanced NEO surveys such as NEOCam. More specifically, we have developed and tested an integrated cognitive system that can reason over available data to reach conclusions consistent with scientists' reasoning and feed the results into a custom-designed ranking algorithm. The system is based on the theory of Fuzzy Cognitive Maps (FCMs) and the TOPSIS (Techniques for Order Performance by Similarity to Ideal Solution) ranking algorithm. FCMs are modeling techniques that follow an approach similar to both human reasoning and human decision-making processes Such FCMs are designed by active interaction with NEO scientists and domain experts that are key to determine the critical concepts and their causal relationships. The influence matrix between concepts are elicited by capturing expert opinion and weighting strength of the connections between parameters. FCMs are fed by available observational data and higher-level products (e.g. impact probability, diameter, MOID) and deployed to achieve inferential conclusions about the candidate NEO target. After convergence, the concepts are fed to the TOPSIS system to autonomously rank the candidate targets. The target list is provided to the operators for scheduling new observations.

Preliminary results and tests using simulated data show that the integrated algorithm is capable of ranking NEO targets consistently with domain expert/scientist reasoning. The system is planned to be an integral component of the NEOCam ground system and can be generalized to any existing or future surveys.

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