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Bayesian Inference of Physical Properties for Impact Scenarios

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ABSTRACT

Physical characteristics of Near-Earth Objects (NEOs) are essential inputs to planetary defense assessments. For instance, the size, density, and strength of an NEO are critical inputs to modeling behavior during atmospheric entry as well as assessing the risk of impact. Similarly, knowledge of the characteristics of an object are necessary to evaluate the probable result of a mitigation mission.

Usually these attributes cannot be directly measured, but increasingly sophsticated methods have been developed to infer physical properties from related measurements of asteroids, meteors, and/or meteorites. Fortuitously, thanks to a variety of facilities (e.g. NEOWise and IRTF), some of these measurements have been obtained for enough NEOs to elucidate the distribution of values across the sampled population. The picture is not so rosy when considering a specific asteroid, however, since it is unlikely that all the relevant measurements have been made for any given object. Furthermore, as learned from the TC4 planetary defense exercise, even when an NEO receives intense scrutiny, measurements of some key quantities may not be possible due to weather and/or facility availability.

We have developed a Bayesian network that can combine available information about a particular NEO with knowledge of the larger population to infer probabilistic values and their uncertainties for physical characteristics of interest. Within the context of planetary defense, this approach can be used to constrain the range of likely impactor properties which can subsequently reduce the uncertainty in modelling results of atmospheric entry, mitigation efficacy, and risk assessment. We will discuss our inference network and demonstrate how it can be used as part of a risk assessment exercise.

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