PDC2023
Vienna, Austria

Topic: Impact Effects & Consequences

Consequences of Asteroid Characterization on the State of Knowledge about Inferred Physical Properties and Impact Risk

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Keywords: *risk assessment, physical properties, impact scenarios*

ABSTRACT

Physical characteristics of Near-Earth Objects (NEOs) are essential inputs to planetary defense assessments. 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 physical characteristics of an object are necessary to evaluate the probable result of a mitigation mission.

Usually, these attributes cannot be directly measured, but increasingly sophisticated methods have been developed to infer physical properties from related measurements of asteroids, meteors, and/or meteorites. Fortuitously, some of these measurements have been obtained for enough NEOs to elucidate the distribution of values across the sampled population. However, the situation becomes more challenging when considering a specific asteroid, since it is unlikely that all the relevant measurements have been made for any given object.

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 uncertainties for physical characteristics of interest. Distributions of asteroid population albedos, taxonomic classes, and macroporosities, along with meteorite density distributions and associations between taxonomic classes and meteorite classes, provide the default distributions for the network's parameter nodes. The inference network links parameters for each virtual asteroid either deterministically or probabilistically as appropriate, and eliminates any unphysical combinations of parameters.

Within the context of planetary defense, our Bayesian network can be used to constrain the ranges of likely impactor properties, which can subsequently reduce

the uncertainty in modelling of atmospheric entry, mitigation efficacy, and impact risk assessment. When additional measurements become available for a specific object, the network incorporates those measurements to generate virtual asteroids with property distributions that are consistent with the measurements. We will use the 2023 PDC scenario to demonstrate how the inference network can be combined with plausible characterization measurements to refine the state of knowledge about likely combinations of physical parameters and the resulting impact risk.

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