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A NEW TERMINAL GUIDANCE SENSOR SYSTEM FOR ASTEROID INTERCEPT OR RENDEZVOUS MISSIONS

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ABSTRACT

This paper presents the initial conceptual study results of a new terminal guidance sensor system for asteroid intercept or rendezvous missions. The proposed sensor system comprises of visual cameras, infrared seekers, and/or radars. As was demonstrated by NASA's Deep Impact mission, visual cameras can be effectively utilized for hypervelocity intercept terminal guidance. Other systems such as Raytheon's EKV (Exoatmospheric Kill Vehicle) employ a different scheme that utilizes infrared target information to intercept ballistic missiles. Another example that uses infrared information is the NEOWISE telescope, which is used for asteroid detection and tracking. This paper explores the use of visual, infrared, and radar devices for asteroid intercept or rendezvous missions. It describes the signal-to-noise ratio estimation problem for infrared sensors, minimum and maximum range of detection using radar, and computational validation using GPU accelerated simulations. Small targets (50 to 100 meters in diameter) are considered, and scaled polyhedron models of known objects, such as the Rosetta mission's Comet 67p/C-G, OSIRIS-REx's Bennu, and asteroid 433 Eros, are utilized. A parallelized ray tracing algorithm to simulate realistic surface to surface shadowing of a given celestial body is developed. By using the simulated models and parameters given from the formulation of the different sensors, impact mission scenarios are used to verify the feasibility of intercept a small target. The simulations use similar parameters to those of the NEOWISE telescope, along with Cassegrain telescope design for IR cameras. With the signal-to-noise ratio formulation and camera specific, IR-based terminal guidance simulations are conducted. It is assumed that the target center of mass is approximately known. Monte Carlo

simulations resulted in 98 percent chance of intercepting a small target. Future work involves onboard target trajectory prediction for a fully autonomous spacecraft.