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Nvidia Omniverse for Active Space Debris Removal Missions, an Overview

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Earth orbits have an increasingly worrying space debris pollution problem caused by millions of human-made objects left in space. These are becoming a hazard for current and future space missions. Many solutions to deal with space debris problems have been proposed, including Active Space Debris Removal (ASDR) methods. In this thriving field, various technologies are under development, among them, systems based on tethers, nets, lasers, or robotic arms can be found. However, testing such systems on earth is challenging, recreating space-like conditions, such as accurate contact dynamics under microgravity, is particularly difficult. Nonetheless, it is of paramount importance to offer testing environments for clean space technologies, as space is unforgiving, and space devices must go through thorough evaluation processes to ensure peak efficiency. The HELEN project aims at fulfilling this very need. Building on one of the most advanced simulation frameworks, it will provide photo-realistic rendering, an accurate physical simulation of the space environment, and eventually, through Hardware-In-the-Loop (HIL), simulation of microgravity in ground facilities. This project is the result of the collaboration between SpaceR (University of Luxembourg), and Spacety (Industry). This simulation will be used to test FlexeS, an ASDR capturing system, which is under development.

In HELEN, the accuracy of the physics is particularly important, as FlexeS will be validated through simulated HIL scenarios. Hence, a lifelike depiction of the microgravity environment, as well as the collisions, is critical. Moreover, to intercept and grab the debris FlexeS will rely on computer vision algorithms, thus photo-realistic graphics, allowing for lifelike visualizations are required. Furthermore, for future HIL testing, the ROS bridge and real-time communication capacity are crucial to connect the virtual world with the Zero-G robotic facility of the University of Luxembourg. In such a manner, FlexeS will be visualized in the space surroundings while simultaneously undergoing hardware experiments. With all these constraints in mind, Nvidia's Issac Sim was selected to create on-orbit dynamic scenarios. It not only meets all the requirements above but also provides a variety of sensors.

Consequently, HELEN is creating on-orbit simulations featuring a CubeSat embedded with FlexeS, and debris circling the Earth. The scenarios showcase the digital twin of the capturing system intercepting debris, corresponding to the approaching phase in ASDR missions. Visually speaking, the RTX render engine allows for photo-realistic image generation. Regarding the motion of these objects, force-based astrodynamics is implemented into the simulation following the gravitational equation. Faithful velocities,

position, and contacts are inferred by Nvidia's physics engine, PhysX. Scaled real-life values are used for the mass, as well as the orbital velocity and altitude. Thus, accurate simulations of contact dynamics between the system and the debris can be achieved. In the future, using a ROS bridge, the simulation will be connected to the HIL testing system of the Zero-G facility, amounting to a wholesome ASDR testing framework.

Overall, the realistic simulations created with Isaac Sim are promising for analyzing clean space technologies. They combine photo-realistic scenes, accurate physics, and in the future, a means to test real hardware systems.