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Real-time problem solving at the Lunar South Pole

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Abstract: The lunar south pole has been proposed by world space agencies as a location for future exploratory moon missions. This region experiences large variations in lighting conditions, with areas of permanent sunlight and shadow, and highly dynamic areas which undergo frequent and dramatic changes due to the horizon topology. These lighting conditions pose unique challenges when planning lunar exploration missions and evaluating engineering solutions.

We used our Lunar Con-ops and Mission Planning tool - our lunar environment for Unreal Engine - to develop a subsystem for positioning solar system light sources, such as the Sun and Earth, in space for any given epoch with sub-second precision, allowing us to compute the required lighting parameters such as color, intensity and incident angles. We combined these parameters with topological data recorded by the Lunar Reconnaissance Orbiter Camera to render realistic shadows on the lunar surface. The positioning system, driven by authoritative data provided by NASA's Jet Propulsion Laboratory, is capable of calculating lighting parameters at rates exceeding 100Hz on representative hardware, allowing for real-time and accelerated lighting simulations. The combination of realism and performance enables a broad range of capabilities.

In this presentation we will briefly explain the structure of the lighting simulation and how the environment was built. We will further describe some of the challenges posed by the lighting conditions on the lunar south pole and how the light source positioning system enabled rapid solutions.

Next, we will show a method for vehicle path planning in a rapidly changing traversibility environment, where vehicle movement is restricted not only by surface topology but also by dynamic lighting conditions. A state-of-the-art route planning algorithm integrated with the mission planning software allows us to discover optimal paths between points, considering the need for adequate charging opportunities and avoiding steep slopes. Finally, we will demonstrate the flexibility of the system, which is capable of simulating arbitrary objects in space such as orbital vehicles. By pre-calculating the trajectory of a space vehicle and resolving its position for specific times, we are able to perform three-way line-of-sight calculations between a geographic location on Earth, the space vehicle, and ground vehicles on the lunar surface. We will show through these examples that our light positioning system is flexible enough to inform a variety of moon-based capabilities, both in a real time and in advance of mission planning, and is a valuable tool in the preparation for future space missions.

Keywords: *Interactive, simulation, space, lunar, lighting*