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LIGHTWEIGHT VISION-BASED BEV OCCUPANCY MAPPING FOR AUTONOMOUS LUNAR ROVER OPERATIONS USING LIDAR-BASED GROUND-TRUTH

Abstract

Rover autonomy is a key capability for sustained lunar exploration. Rovers must perform reliable hazard detection and terrain assessment under strict constraints in mass, power consumption, and onboard compute resources. Vision-based Bird's Eye View (BEV) occupancy networks have demonstrated strong spatial reasoning performance in terrestrial autonomous driving; however, their ability to generalise to lunar environments—characterised by extreme illumination contrast, low-texture regolith, and sparse geometric structure—remains largely untested. In addition, annotated lunar datasets suitable for training such models are scarce. This work investigates whether a vision-based BEV occupancy network can learn and reproduce a geometrically consistent occupancy representation in lunar-like appearance conditions while remaining compatible with embedded rover-class hardware working in real time. The study aims to evaluate feasibility rather than to establish state-of-the-art benchmark performance. We obtain supervision from an offline LiDAR–camera pipeline (LG-Occ) that builds ground-referenced BEV obstacle occupancy from temporally aggregated LiDAR geometry and produces per-camera line-of-sight visibility masks through voxelised occlusion reasoning. We introduce SimpleBEV-Lite, a lightweight adaptation of SimpleBEV designed for deployment on embedded platforms such as NVIDIA Jetson Orin–class hardware and FPGAs. Architectural simplifications reduce computational complexity and memory footprint while increasing spatial reasoning capacity. The model is trained on lunar and lunar-analogue rover datasets, including LunaPolaris. The evaluation focuses on occupancy and path-planning metrics. Analyses indicate that the network maintains a coherent occupied and free-space structure under lunar-like visual conditions. The lightweight architecture demonstrates compatibility and real-time effectiveness on embedded compute. Preliminary results indicate a 2x increase in the networks' inference rate whilst increasing occupancy average precision by 5