Defense Announcement

Small Spacecraft Design & Machine Learning-based Approaches To Lunar Robotics N

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Since human exploration of the Moon in the 1960s, the lunar community has benefited from a series of successful missions, including flybys, orbiters, landers (crewed and robotic), rovers, and impactors. The next generation of lunar exploration will include a cis-lunar station, crewed missions, and in-situ resource utilization (ISRU)-based missions. Complete utilization of the currently available technologies is vital to effectively plan and execute future missions. This can be facilitated by two key technologies: small satellites and machine learning (ML). Nowadays, satellite technologies have progressed to the point where off-the-shelf components can be purchased for small-satellite missions, greatly reducing the time and cost needed to prepare a new mission. The rapid escalation of the production and launch of small satellites has revolutionized the space industry, proving that small satellites in constellations are more useful than fewer, larger ones for some scientific missions and radio relay missions on a large scale. ML and artificial intelligence also play an increasingly important role in aerospace applications, particularly for automated systems, including space robotics guidance, navigation, and control. This thesis aims to demonstrate three potential components that small satellites and ML could help accelerate in view of future exploration of the Moon and other planetary bodies. The discussion is divided into three topics: 1) renewal of lunar navigation systems with small spacecraft, 2) a machine learning-based approach to lunar hopper control, and 3) a machine learning-based approach to small rover path planning. In the first topic, a new triangulation theory that enables the creation of lunar global navigation satellite systems with just two small satellites is introduced. In the second topic, a new ML-based methodology for lunar hopper obstacle avoidance, descent, and landing is presented. In the third topic, a new ML-based global path planning methodology for small lunar rovers is proposed.