IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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HUMAN-ROBOT PARTNERSHIPS AND FUTURE EXPLORATION OF THE LUNAR SURFACE

Abstract

The synergy between human intellect and robotic precision is reshaping the landscape of space exploration, enhancing mission capabilities and extending the reach of humans beyond Earth. Advancements in robotics and artificial intelligence have ushered in an era where machines are increasingly capable partners in exploration endeavors. However, the significance of human expertise and intuition remains irreplaceable. As we prepare for future scientific exploration of our moon, the integration of human-robot teams becomes paramount. Complex mission designs necessitate a delicate balance between leveraging robotic autonomy and harnessing human adaptability. Intelligent systems equipped with machine learning algorithms enable robots to autonomously navigate and execute tasks in challenging environments, thereby augmenting human capabilities and access as well as ensuring mission success. New robotic operations are in development to support joint human-robotic lunar exploration missions. For the human partner, these activities include: 1) Situational Awareness with 3D maps and robot status; 2) Scientific Awareness, visualizing data from robots in real-time; (3) Decisions and Planning for the mixed human-robot teams, and (4) Command and Control of robots from teleoperation from remote sites to task-level commands. The developments will focus on enhancing the scientific awareness and efficiency of a robot operator to maximize the effectiveness of a scientific exploration mission. The ongoing deployment of robotic precursors will play a pivotal role in new technology validation as well as reconnaissance and resource prospecting, laying the groundwork for sustained human presence on the moon and, eventually, other worlds. These robotic scouts are paving the way for strategic decision-making, optimizing resource utilization and mitigating risks associated with human exploration. Looking ahead, AI unlocks novel dimensions of human-robot partnerships in long-term exploration endeavors. Intelligent robotic companions, infused with advanced AI algorithms, will transcend their conventional roles to become empathetic collaborators. These AI companions will leverage natural language processing and emotional intelligence to foster meaningful interactions with astronauts, mitigating the psychological challenges of prolonged isolation and enhancing crew cohesion and well-being. Furthermore, AI-driven predictive maintenance systems ensure the resilience and longevity of critical First presenting new, initial results of timed human-robot teaming experiments my colleagues and I have conducted in volcanic caves in California, I will introduce our findings in the context of related operational strategies in development today and offer rationale for why these will optimize science return from future missions to challenging environments on the Moon and beyond.