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EVOLVING HUMAN-ROBOT INTERACTION IN SPACE: LESSONS FROM ASTROBEE AND FUTURE APPLICATIONS

Abstract

As human spaceflight advances toward long-duration missions and commercial space station operations, integrating robotic assistants is essential for improving crew efficiency, mission sustainability, and overall system resilience. This paper explores the evolving role of human-robot interaction (HRI) in space, focusing on robotic assistants like NASA's Astrobee aboard the International Space Station (ISS) and their potential applications in future habitats. Drawing from astronaut experiences and insights from the Astrobee Working Group, we examine the challenges and benefits of robotic assistance in microgravity, including autonomy, perception, and task execution. Using the Environment-Vulnerability-Decision-Technology (EVDT) framework, we outline key considerations for designing future HRI architectures that enhance crew support, habitat maintenance, and mission adaptability. As a case study, we highlight the MIT Space Enabled Zero Robotics program's use of Astrobee for hand gesture detection, demonstrating how intuitive human-robot interfaces can streamline operations and reduce cognitive load for astronauts. Looking ahead, we discuss how advancements in robotic perception, autonomy, and AI-driven decision-making will shape the future of human-robot space partnerships. By anticipating these developments, we can better define the roles of humans and machines in upcoming exploration missions, ensuring seamless collaboration in increasingly complex and autonomous space environments.