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THE ROLE OF ARTIFICIAL INTELLIGENCE AND AUTONOMY IN THE FUTURE OF SPACE EXPLORATION: OPPORTUNITIES, CHALLENGES, AND IMPLICATIONS

Abstract

The rapid advancements in Artificial Intelligence (AI) and autonomous technologies are reshaping the future of space exploration, driving missions beyond the limits of human capability. This review explores the profound impact of AI on various aspects of space missions, including autonomous navigation, planetary exploration, real-time data analysis, and decision-making. AI-enabled systems offer enhanced efficiency, reliability, and adaptability in deep space missions, where communication delays and harsh environments demand real-time autonomous operations. From autonomous spacecraft and rovers to AI-driven scientific discoveries, this paper highlights the transformative role of AI in enabling long-duration missions, optimizing resource management, and mitigating risks in space exploration. The review also addresses the challenges associated with implementing AI in space, such as the need for reliable verification, cyber security risks, and computational limitations. Finally, the paper outlines the future trajectory of AI and autonomous systems, including their potential to support human-AI collaboration in interplanetary missions, space colonization, and beyond. As AI continues to evolve, its role in space exploration will be pivotal, unlocking new frontiers for scientific discovery and expanding humanity's reach into the cosmos.