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THE USE OF EXTENDED REALITY (XR) TOOLS FOR SPACE TRAINING AND EDUCATION PURPOSES: NEXT CHALLENGES AND RESEARCH GAPS

Abstract

This paper explored the current and prospective applications of Extended Reality (XR) technology in training and education within five space domains. XR, encompassing Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR), provides immersive experiences for lifelike scenarios and real-time guidance during non-routine tasks. The exploration covers XR research and ongoing projects, examining its utility in astronaut training, addressing microgravity challenges, enhancing space situational awareness (SSA) and space traffic management (STM), facilitating technicians and operators training, preparing individuals for space tourism, and contributing to space education (e.g., during astronomical classes). In astronaut training, XR tools at facilities like the European Space Agency (ESA)'s XR lab and National Aeronautics and Space Administration (NASA) JSC Virtual Reality Lab simulate operations such as extravehicular activities and interaction with robotic arm operators, incorporating features like zero gravity mass simulation. For SSA and STM, XR tools could train operators (e.g., military officers) using live satellite data. In the technician and operator training domain, XR creates secure environments for practicing complex maintenance tasks e.g., the ICARUS project, a VR system designed for teaching technicians satellite building (e.g., the CubeSats). Simultaneously, XR tools could have the capability to replicate mission control scenarios, specifically designed for training purposes. Further, addressing challenges in space tourism, XR bridges the gap between minimal public-tourism willingness to train extensively and the need for thorough preparation. Finally, in the space education field, XR tools like tailored VR programs for students, offer immersive experiences for hands-on experiments, contributing to interactive learning environments related to space exploration. These are just a few examples within these five domains. Recognizing knowledge gaps in space training and education underscores the importance of examining the XR's role in enhancing interactive learning environments for space-related activities. This paper explored the potential of XR tools to enhance training efficacy and prepare individuals for the challenges related to space activities (e.g., space exploration) by identifying research gaps and opportunities.