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DESIGN OF AN AR-IOT TOOL FOR FUTURE HUMAN SPACE EXPLORATION

Abstract

Humans are embarking on a new era of space exploration with the plan of sending crewed spacecraft beyond Low Earth Orbit (LEO) to the Moon, Mars and beyond. This plan entails many challenges as real-time ground support cannot be provided to astronauts during operations. Therefore, modern human-machine interfaces have to be designed to support astronauts during their deep space missions. Augmented reality (AR) has found a broad range of applications in many domains including the space industry, specifically for procedural work. Several studies have been performed on the effectiveness of AR in assisting procedure-guided tasks for both on-board and on-ground operations, however most studies provided qualitative rather than quantitative results. Based on the research currently performed regarding Internet of Things (IoT) technologies in combination with AR for visualization and enhanced situational awareness purposes and accounting for the lessons learnt from the Apollo program and the International Space Station (ISS), the present work investigates the benefits obtained through the use of these technologies applied to future planetary human space exploration. The purpose of this research is to quantitatively evaluate whether an AR-IoT concept is an effective and efficient tool able to support future planetary surface exploration missions and aid in human-machine interaction. Interviews with experts at the European Astronaut Centre of the European Space Agency (EAC-ESA) were held to gain insights on present and foreseen issues as well as operational scenarios related to human space missions. A user-centered design method was used to design the AR interface, deployed on the Microsoft HoloLens, integrated with an IoT setup of different devices. To evaluate the effectiveness and efficiency of the developed tool controlled experiments, using subjective and objective metrics, were performed with a number of test subjects at EAC-ESA. The criteria used included: mental effort, completion time and error rate. The AR-IoT concept is indeed enhancing situational awareness, increasing work efficiency and reducing users' mental effort. This study helps understand the benefits of AR in the integrative IoT system for future deep space manned missions.