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MOBILE AUGMENTED REALITY FOR SPACE OPERATION PROCEDURES: A GENERIC APPROACH OF AUTHORING AND GUIDING ON-BOARD PAYLOAD ACTIVITIES

Abstract

Procedural guidance as a strong tool for ensuring precise task performance is an essential factor for success or failure. In human spaceflight standardized procedures have been always applied to operate the systems on-board the ISS, like maintenance and mission specific tasks at payloads. Thereby strictly formatted procedures serve as a guideline and provide a list of directives to be followed exactly. For every performed operation, the flight crew uses a set of Operations Data File (ODF) procedures that are generated by using the Procedure Authoring Tool and stored as XML files that can be executed by the International Procedure Viewer at the Crew Commanding Station (CCS). This forces the crew member into constant gaze changes between the CCS and the payload, which can lead to loosing the intended focus, loss of concentration and increased workload. Augmented Reality (AR) as future interface technology allows a natural integration of computer generated information into our physical world and closes the gap between virtual and physical reality. Thereby displays wearing in front of the eyes or handheld retain our gazed focus of target. In this paper we present a generic approach of authoring and guiding Augmented Reality supported ODF procedures that allows easy composing of AR procedures extended by visual resources applied to a virtual payload model and provides a corresponding guidance tool using head-mounted displays, that allows intuitive exploration of a payload, displays adequate head-up display information (e.g., ODF instructions) and 3D related information (e.g., labels, 3D objects), and embeds informational resources, like images and videos. To be hand-free in operating, we realized voice control for sequentially going a step forward and backward. For comparing the performance and general acceptance of the AR guidance system with the conventional method using the CCS, we conducted a formative expert user study at the ESA's European Astronaut Centre (EAC) in Cologne, Germany. By using representative ODF procedures, we designed different experimentation tasks that were performed by ten subjects under both guiding conditions in a within-subject study design. Although nine subjects are instructors at the EAC and used to handle ODF procedures, the objective measurements showed that the completion time of the AR system was partially faster and it ensured the sequential instruction order, which was a frequent problem while performing under the conventional method. The subjective measures showed that using the AR system improved the performance by decreased workload and was mostly preferred.