AROGAN
'Augmented reality based orbit and ground applications'

4000127710/19/NL/GLC
Procedure viewer and authoring tool for ground AIV/AIT applications

ABS - Abstract

ABSTRACT

This abstract report introduces an Augmented Reality system for the space industry and the three use cases of the project called AROGAN - 'Augmented reality based orbit and ground applications'. The project outcome is a solution of authoring system and augmented reality visualizations for IPV procedure with AR capabilities. AROGAN system exploits the mobiPV IPV procedure viewer, which database has been expanded with AR capabilities. Report also introduces of design of AROGAN system and outcome of user evaluations. End of the document high-lights lesson learnt and future extensions.

Main objective of this activity is to verify if Augmented Reality (AR) could be eligible technologies and productive tools for AIT/AIV activities. The main sub-objectives of the proposed development are to:

- Extend the current IPV procedure viewer with AR capabilities
- Adapt the current IPV procedure viewer with light and heavy manual procedure
- Develop an AR authoring environment for the 2 above defined procedure types
- Demonstrate the process and technology with an IPV procedure – authoring and execution

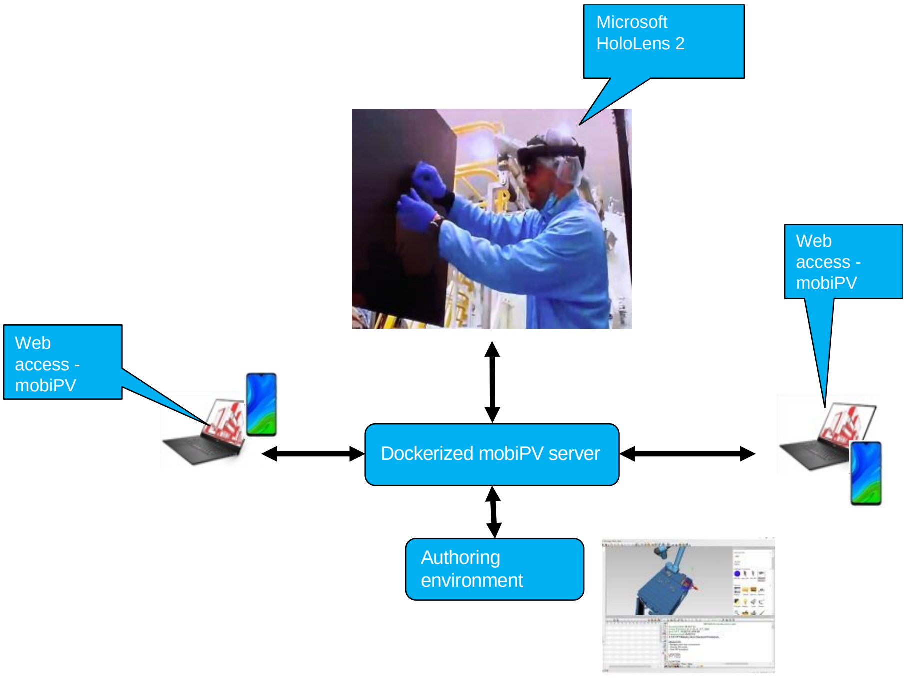

Figure 1. AROGAN system set-up

The operational AROGAN MR-systems and authoring components can be found in Figure 1. System includes:

1) Microsoft HoloLens 2 with AROGAN AR-player app,
2) mobiPV – server for all Operations Data File (ODF) content, AR annotation and 3D models with animation
3) mobiPV's web interface, which also allows to the user interact with systems
4) Authoring environment, which is including on-site and off-site authoring.

To verify the main project objectives, three most relevant use cases were selected. Two of them were use cases at ESTEC premises and the third was used base line for development and early phase user evaluations (see Figure 2).

1) AR supported installation of thermocouples on the Solar wind Magnetosphere Ionosphere Link Explorer – SMILE
2) AR supported phase 2 sensor installation for testing campaign with TEDY (TEst DummY)
3) VTT Robotic arm checkout procedure with AR

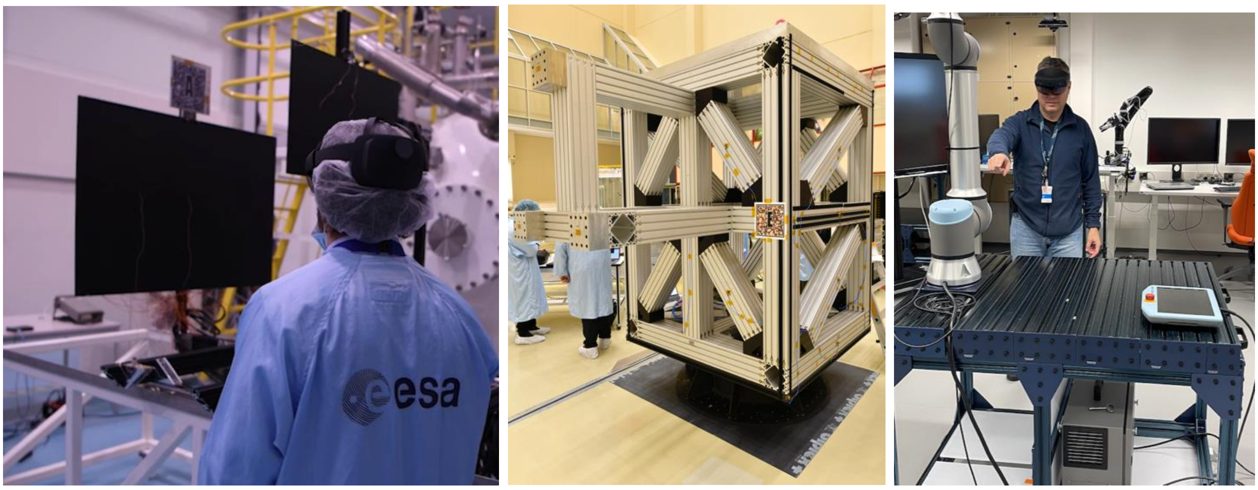

Figure 2. The AROGAN use cases. Left: Thermocouples installation to SMILE. Middle: Sensors installation to TEDY. Left: Robotic arm checkout procedure

The user evaluation was done in two phases: preliminary and final user review. Test cases include SMILE heated plates test procedure, TEDY phase 2 sensors placement and VTT Robotic arm checkout procedure. The evaluations have been performed remotely via online tools due to COVID-19. The methods for data collection have included observation, interview and questionnaire. The main focus of the reviews have been on usability, user experience, and usefulness of the AR-system. All the reviews have been performed during 2021.

Generally, the AR-system is seen to have the potential to improve the work task (and similar tasks) that was performed during the test. Currently, the sensors have to be placed based on printed CAD models and guides. The AR-system can significantly speed up the work. The AR system is envisioned to improve productivity and efficiency when working with complex structures and procedures. For simpler use cases the current approach is sufficient. The AR-system also provides positive and stimulating novelty value, described as “something out of a sci-fi movie”

The results of the user reviews suggest that the developed AR-system has potential to become a useful tool for AIV/AIT applications. The AR-system can significantly speed up the current work and provide motivating novel tool for the operators and engineers. The users’ overall reaction to the system was positive. The system usability scale (SUS) scores were quite high in both test phases indicating already acceptable system usability. All the individual scores from the final user review reached the range of acceptable usability and were thus slightly improved from the preliminary test phase. It should be noted that the main test users in the final review were actual operators performing their real work task.

Very interesting AROGAN extension could be the ODF link to telemetry for system/devices monitoring function. Augmented Reality is in general very useful in showing physical objects and indicating operations to be performed on real hardware while it is usually of little or no use when the operator has to perform for instance monitoring and control operations on a computer. AROGAN system could be connected to real devices and thus exploit telemetry or similar data in AR e.g. via MQTT interface. This future capability could therefore be exploited very conveniently during the execution of ODF procedures when the operator has to monitor parameters data while performing the task. Just as an example, when ODF procedure provided by mobiPV gives instruction for setting a parameter (i.e. a pressure) at a certain value, AROGAN system can also provide, nearby the interface to be operated, the real-time value of the parameter so that the user doesn't have to jump back and forth from the setting place (i.e. the valve pressure regulator) to the device displaying the telemetry (i.e. the Portable WorkStation laptop). This will save crew time and prevent errors during procedural task execution. The picture below shows an example where the ESA-EdcAR Demonstrator displays in AR pressure telemetry data just nearby the physical pressure regulator valve (See Figure 3).

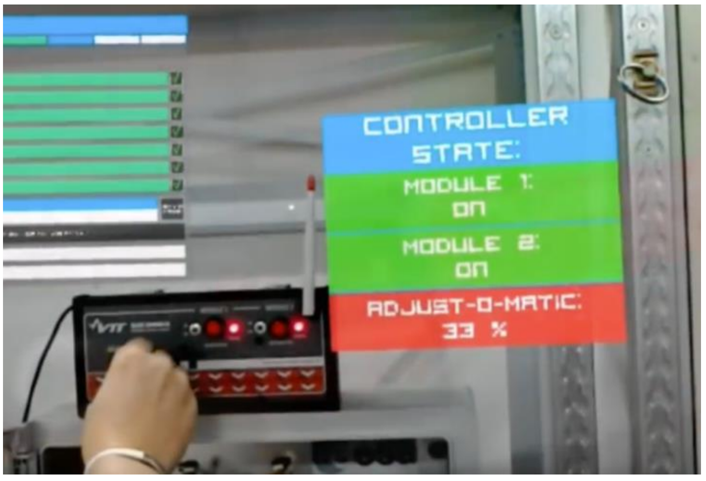

Figure 3. Telemetry data shown in Augmented Reality

Besides the visualization in AR of instructions delivered by mobiPV and concerning procedural steps to be executed, AROGAN system can furthermore provide the crew with different types of additional information relevant to the task to be performed. One of the main benefits of augmented reality is to make invisible content visible and give correct information in correct place in right time. AROGAN with AR X-ray function can provide a useful support to the crew during training sessions as well as during operations on real hardware (See example Figure 3).

AROGAN system could be enhanced to eXtented Reality (XR) side. This gives several opportunities to enhance AIT/AIV from design to actual AIT/V activity. The continuum from design via training to actual work support, with same data and annotation visualization, only level of immersion is changing. This allows users and designer new opportunities to support AIT/AIV activities with same data structure: (1) Design and content authoring in VR, (2) Training in VR/MR, and (3) AIT/V support via MR/AR.

Last but not least, AROGAN system could be tested in ISS with real end-users as it has been connected to mobiPV which has been tested in the ISS. This wider area to use AR system and allows to get ergonomic evaluations and refinements in other area, and then close the loop for a correct human centred design approach.

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