Augmented Reality Applications
for
Human Space Exploration & Operations

Lui Wang

Software Robotics & Simulation Division
JSC/JSC

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Augmented Reality Crew Assistance

• Objective:
  – Enhance crew/operator real-time performance and experience by using AR technology

• Operational Crew Task includes:
  – Procedural Task Execution Support:
    • Operational procedures of complex systems
    • Medical procedure guidance
    • Inventory Logistics Operations
  – Data Visualization and monitoring
AR Development Activities

• Assessment of different hardware (HoloLens, ODG, Vuzix, Tablet, …)

• Assessment of different AR SDK (Vuforia, ….)

• Developed a full integrated suite of tools for AR-enabled electronic Procedures
  – Allows for fast development of complex procedure guidance applications
  – Toolset includes Procedure Representation Language, Procedure Execution Engine, Web Procedural Display, AR Editor, Procedure Authoring tool, …
AR Applications

• Development of the following AR apps:
  – ARED
  – T2
  – TOCA
  – MED (NEEMO20,21,…)
  – Stowage/Logistics/Inventory
  – Medical FAST procedure
  – OCT Protocol Assistant
  – FUS Procedure Guidance
  – Immersive Design Visualization System
  – 20ft Chamber

• Other activities:
  – Integration with eProc
  – PhotoOpp
  – Adaptive UI
ARED Case Study

- **ARED - Advanced Resistive Exercise Device**
  - Difficult and complex maintenance procedure
  - AR application guides the crew in performing maintenance procedure (Cylinder flywheel evac) by displaying procedure steps and associated visual cues (arrows, pointers, …)
TOCA Case Study

- **TOCA** - Total Organic Carbon Analyzer
  - On-board ISS maintenance procedure
  - AR application provides guidance to the crew in performing filter cartridge replacement procedure
NEEMO Activities Case Study

- **NEEMO**: Extreme Environment Mission Operations:
  - NASA analog mission that sends groups of astronauts, engineers and scientists to live in Aquarius, an undersea research station, for up to three weeks at a time

**Miniature Exercise Device (MED): Test of an AR based Just-in-time-training for Assembly & Dis-assembly Tasks**

**AR application for Sani-tank Purge Procedure (Glass, ODG, HL)**
**T2 Case Study**

- **T2 Treadmill- On board ISS Exercise equipment**
  - AR application provides guidance to the Crew in performing T2 snubber pin alignment procedure and T2 Inspection Procedure.
Hardware Locator Case Study

- **DSH- Deep Space Habitat Hardware Locator:**
  - AR Application provides “X-Ray Vision” by helping crew locate different pieces of equipment such as Power System components, sensors and behind the wall computer and network devices.
AR for Logistic & Inventory

- Aid the crew in gathering parts and tools required for specific activity
- Provide “X-Ray” vision of racks content.
- Support transfer of cargo items from spacecraft to habitats, as well as habitat stowage tracking.
- Display the cargo unpack and packing ops procedures choreography steps into the glasses device
- Use gesture, touch or voice control to navigate the procedures
- Provide Automatic update to the inventory database
- AR application to support Cargo Transfer Operations
  - Unpack cargo list
  - Packing cargo list

Cargo Ops Messages (Procedures)
- Cargo Ops Overview
- Cargo Unpack List
- Cargo Launch Maps
- Cargo Pack List
AR Medical Procedural Training

- AR-based Spaceflight Procedural Training
  - Goal: Migrate ultrasound and OCT training materials to be used on AR platform to improve training and procedural competence
  - Currently, astronauts receive remote guidance, two-way communication with experts in Mission Control, in near-real time to perform medically-required procedures.
  - The delivery of instructional material in real time represents a significant improvement in the ability of astronauts to conduct medical imaging autonomously.
**Flexible Ultrasound System (SBIR)**

- Developed platform for autonomous AR interface to next generation spaceflight ultrasound
- The platform
  - Controls the UltraSound device
  - Displays procedural instructions
  - Provide 3-dimensional probe guidance
  - Uses neural network for image processing to optimize procedural outcomes.
- The AR system highlights starting ultrasound scanning locations on the subject’s body
• **Optical Coherence Tomography (OCT)**
  – Developed autonomous AR interface for Ocular Health (OH) vision test in the Harmony node of the International Space Station.
  – The OH experiment observes and seeks to understand vision changes during long-term space missions.
  – AR application provide procedural instructions and 3-dimensional guidance to help obtain good Retinal images.
  – In the backend the AR app utilizes neural network to assess image quality.
  – AR application provide real-time feedback to the scanner based on the image generated on the OCT system.
AR Alignment Methods

- **Marker-less Manual 3 Points alignment**
  - Leverage on HL spatial map
  - Manually taps the points (anchors) to place in the real world
  - Adjust the anchors to align with the real world
  - Spatial anchors are saved and future alignments are not necessary

- **Marker (Vuforia) Automated Alignment**
  - Leverage on Vuforia’s vision based library for initial alignment
  - Disable Vuforia alignment
  - Use HL for tracking
  - Required calibration every session; can’t save Vuforia alignment
Gaze Tracking Heat Map

AR application that generates a heat map by tracking the user’s gaze

Multiple intended use cases:

• Assess how people react in emergency situations,
• Usability studies on hardware,
• Evaluation related studies
• Any situation where a person’s gaze can tell a deeper story than what they might tell you verbally.
AR-enabled eProc & Adaptive User Interface

- Next version of our toolset:
  - Add AR capability
  - Integrated development environment for AR within the eProc toolset
  - Some procedures steps are authored to be executed using AR device to guide the operator in specific tasks
AR apps in work/future

- Photo opportunity on-board International Space Station (ISS):
  - AR app provides the astronauts with visual cues from ISS window to help identify interesting earth observation photo opportunities

- Robonaut Control and visualization
  - AR app provides on-board ISS Robonaut arm and hand control and clearance visualization

- Onboard ISS Visualization
  - AR app provides visualization of interior constraints, emergency path, traffic flow

- Immersive Design Visualization Task Assessment Evaluation
  - AR app provides for maintenance R&R, plug-in plan, vehicle reconfig