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The Development of Augmented Reality Tools for Enhanced Criticality Safety and Documentation in Gloveboxes

Los Alamos National Laboratory - Engineering Institute, Criticality Safety Division

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Augmenting human senses can help reduce administrative criticality safety violations while working in gloveboxes
Motivation

- Consequences of infractions
  - Lost time
  - Pause or stop work scenarios
  - Regulatory citations that reflect poorly on facility operation

Project Goals

- Reduce the number of technical criticality infractions due to proximity.
- Provide a useful human interface to facilitate glovebox work and improve quality.
- Specific proposal goal: Full-scale functioning system in nuclear facility at LANL
Have the system connect to databases and instructions for running processes. Improve the ability to document work in a hands-free manner.
Concept flowchart

A Priori Information

Sensor

Glovebox Environment

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Audio and Visual Warning System

Human Operator

World Model

MC&A System

Reasoning

Object recognition

Marker recognition
Solution requirements

- Identify materials in glovebox
  - Type
  - Location
- Real-time response
  - Buffer zone
- Unobtrusive
- Operator friendly interface
  - Alarms, display
- Flexible, adaptable, for installation in unique glovebox environments

Example material canisters
Technology involved (Spring 2014)

Visual Markers
- Uniquely track materials
- Simple, easily modified

Microsoft Xbox 360 Kinect
- Recognize symbols
- Measure 3D coordinates

Robot Operating System (ROS)
- Modular software
- Integrates hardware
  - User friendly

Alarms
- Easily recognizable
- Real-time response
Bringing it all together in a glovebox

- Provides real-time feedback to alert operators to potential criticality infractions

![Diagram showing Kinect and alarm system with uniquely marked canisters]
Proof-of-principle

- Kinect sensor and ROS software identify unique symbols and canister 3D locations

Kinect camera view of canisters

ROS GUI 3D coordinate data

<table>
<thead>
<tr>
<th></th>
<th>Canister 1 (red)</th>
<th>Canister 9 (blue)</th>
<th>Canister 10 (green)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X (cm)</td>
<td>8.23</td>
<td>-39.9</td>
<td>-17.6</td>
</tr>
<tr>
<td>Y (cm)</td>
<td>40.8</td>
<td>32.3</td>
<td>25.8</td>
</tr>
<tr>
<td>Z (cm)</td>
<td>125</td>
<td>117</td>
<td>139</td>
</tr>
</tbody>
</table>

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Tracking containers with Depth Imager
Virtual Reality and Augmented Reality Headsets

Google Glass

Summer 2014
The synthesis of sensing, modeling, and augmented/virtual reality
2016 - Commercially Available Augmented Reality headsets have Arrived!

We Use the Microsoft HoloLens

- Windows 10 machine
- **Advanced Sensors and Optics**: Depth camera, RGB cameras, microphones, Inertial Measurement unit (IMU),
- **Spatial Sound**
- **Wireless comms**: 802.11, Bluetooth
- **Spectator Views (3rd Person)**
Spatial mapping is advantageous because it knows where you are and where you have been.

Spatial knowledge is key to information that is

- Relevant to user position
- Relational to the objects that surround the user

HoloLens Internal Spatial Map
Our motivation is to augment a nuclear facility personnel with knowledge using a next generation, human-machine interface tool of the future for the effective, efficient, and safe operation within a nuclear facility.
Concept for a Smart Nuclear Facility

Future

In-Situ Generalized Augmented Reality Nuclear Facility
Augmented reality at the systemic level provides the facility manager with a complete view of real-time actions being performed within the facility.

Goal:
Augmenting the facility operator(s) knowledge with real-time data streams.
The development of the Generalized Nuclear Facility has static and dynamic elements.

**Static Elements**
- Room
- Hallway
- Glove Box
- Drop Box
- Safe
- Cage
- Floor Space

**Dynamic Elements**
- Personnel
- Canisters
- Trolley
- Carts
- Drums

**Glove Box**

**Controlling Sub-Elements**
- Current State of glove box
- Interaction with Dynamic Elements
- Nuclear Material Handling and Movement Documents
The dynamic elements, such as material canisters, within the facility are mobile. Data can be associated with these objects that can be used to facilitate planning, executing, and documenting material moves.
The experiential level operates through controls such as gaze, gesture, and/or voice

*Showcasing gaze and gesture controls
Gaze is performed by targeting an object via a central reticle viewed through the headset.

- **Targeting Reticule**
- **Off-Target**
- **On-Target Triggers Events (Button Enlargement)**
Gestures are performed by the user to initiate an action such as selecting and object.
Voice command gives the user an extra hand for carrying out and completing tasks

Using voice to click buttons, navigate menus, and enter data.
Object tracking is a key skill and is critical to nuclear material handling and movement actions

QR code assigned to a unique object.

HoloLens recognizes QR code and uses its location to set the virtual object’s position.

Position is updated constantly. If image is not visible, last known object position is retained.
An example of nuclear material canister tracking as viewed through the HoloLens

Visually recognizing and tracking two unique objects.
The physics of the canister material can be represented in the augmented reality domain, leading to safer operations.

Using knowledge of two unique objects to alert user that they are too close.
The flow of information from the experiential to the systemic level and back, leads to the development of a smart nuclear facility.

Experiential Level (Technician)
- Collects and Sends Information
- Efficiently Accesses Information

Systemic Level (Facility)
- Coordinates Information/Feedback
- Streamlines Procedures
Tracking motion at human time-scales is a basic research problem we are studying

- Detects only changes in pixels
- Low power
- Captures dynamics at short time scales
- Low Bandwidth Requirements
We are currently working on a variety of Augmented Reality Applications that will Apply to Gloveboxes

- Spectator View
- Embedded Systems, Control of Robotics

- Criticality Safety Evaluations
- File Uploads
- Virtual Educational Facility
- Actual Material Handling and Moves
Questions?
References

Key future work is demonstrating a mock material move in augmented reality
Currently, augmenting reality has a near limitless ceiling lending to unique solutions to tough problems.

Creative solutions to tough problems are only limited by the engineer’s creativity.

Limitless Solutions!

Solution Domain

Challenge Domain

Engineer’s Creativity

Criticality Safety, Topology Optimization, Design, and Analysis, …
Demo Considerations – we should have a way to interface the holens to a screen so people can see what the hololens sees.
Augmented Reality is not just for video games and is primed to revolutionize how engineers, scientists, and technologists perform work.
The LANL’s Engineering Institute Augmented Reality Team has been tasked with developing a nuclear training facility.
At the end of the day the systemic level approach will be the framework for which all elements will interact, thus leading to a smart nuclear facility.

Smart Facility Characteristics

- Real–Time
- Effective Operations
- Efficient Actions
- Safe Guards/Practices
- Machine Learning
- Communication
- Collaboration
- Documentation
Augmented Reality

Systemic Level

Experiential Level

Concluding Remarks

Next Topic
Augmented reality is a powerful tool that allows nuclear facility personnel to interact with glove boxes as well as many other objects.
Next Topic

- Augmented Reality
- Systemic Level
- Experiential Level
- Concluding Remarks