SAND2019-14850C

AR Training: Approaches and Considerations

Nadine E. Miner, PhD

XR Team Lead Software Simulation and Analysis
Sandia National Laboratories
neminer@sandia.gov

Sandia National Laboratories

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND 2019-xxxx x

Overview

Background

Motivation

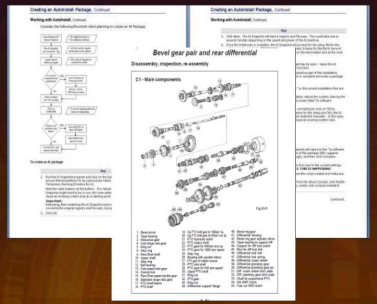
Method 1: Sequential Learning

Method 2: Real-world Facility Training

Method 3: Exploration-based Learning

Future

Background: Traditional Training Methods



Training/Design Manuals

+ Relatively inexpensive to produce, update, distribute
+ Provides Parallel training
+ Captures Procedures
- Lacks visual elements, 2-D
- Not engaging
- Doesn't provide practice

Videos and Power Point Training

+ Adds critical visual element
+ Provides parallel training
+ Demonstrate complex processes
- Not experiential, no practice
- Costly to update

Training with Expert

+ Experiential with feedback
+ Strong visual element
- Doesn't capture knowledge or provide replay/practice
- Not highly parallel
- Expensive
- Time and resource constrained

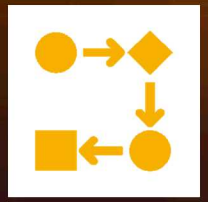
Opportunity for AR Training

BACKGROUND | MOTIVATION | METHOD 1 | METHOD 2 | METHOD 3 | FUTURE

Motivation

- The U.S. Workforce is aging
  - By 2024, 25% of the **US workforce** will be over the age of 55 (Bureau of Labor Statistics)
  - Not enough younger workers to make up for the labor and skill gap that the retired “baby boomers” will leave
- AR Training has potential to help fill this gap and overcome many negatives of traditional approaches
  - Captures knowledge in a more flexible, dynamic, visual way
  - Engages learners in interactive training scenarios
  - Allows parallel and offsite training
  - Engage Learners in Interactive Training Scenarios
  - Allow Practice of What-if and High Consequence Scenarios
  - Increase Retention Through Repetition and Knowledge-Testing

METHOD 1:
Sequential Learning



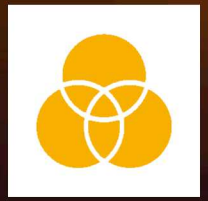
Sequential Training Lends itself to Training Frameworks

- **Sequential ordering of information is fundamental to human learning**
- **Widely needed for a variety of tasks: assembly, disassembly, maintenance**
- **Common functionality across domains**
  - **Demonstrate, Teach Sequences, Test knowledge for increased retention**
- **Make or Buy?**
  - **Develop Custom Training Framework**
    - 6300 XR Team customizable training framework
    - Custom frameworks presented here today
      - Software Product Lines for Immersive Training
      - VEGA: An AR Work Instruction System
  - **Commercial off the Shelf**
    - Many choices
      - Microsoft Dynamics 365 Guides, Vuforia Studio, Adobe Captivate, ScopeAR, ...

Considerations for Training Frameworks

- Many solutions and more to come – Difficult to Choose!
- Considerations for "Make"
  - + Full control over interactivity, feedback, features
  - + Customize features according to your prioritizes
  - + Full control over sensitive information and security
  - – Software system security challenging
  - – Long development time unless large software teams employed
  - – Duplicating feature development available in other tools
  - – Expensive

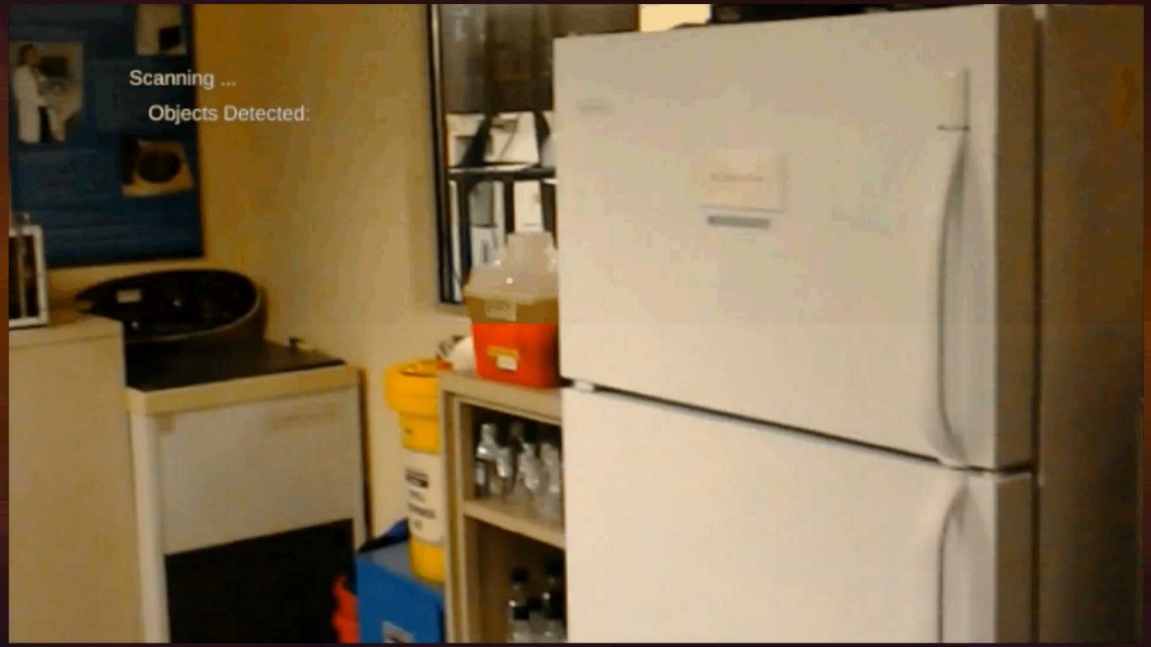
METHOD 2:
Real-World Facility Training with Target Recognition



Training in Real-World Facilities

- Useful for facility training such as operations and inspections
- AR ideal because you can see real-world and overlaid information
- Augmentations can be: graphical, audio, video
- Target recognition is often useful for real-world training
  - Vuforia is a tool that allows creation of custom image target databases and is fully integrated with Unity
  - Vuforia supports HoloLens, Android and iOS

Chem/Bio Lab Facility Inspector Training with Target Recognition



Video SAND No. SAND2019-14637 C

Considerations for Target Recognition

- True object recognition is the “Holy Grail” of computer vision today
  - Can use machine learning to develop object recognizers, but vast amounts of data needed
  - Can develop application-specific object class recognizers requiring less data for well-defined object sets
- Hardware
  - Microsoft HoloLens® v1
    - Target recognition via Vuforia/Unity Good, but sensitive to head jitter, limited FOV and there is lag
    - Anticipating HoloLens ® v2 will overcome many of these limitations
  - Tablets/Smart Devices
    - Have higher resolution cameras with larger FOV
    - Provide faster, more stable target recognition
    - Not hands-free

METHOD 3:
Exploration-based Learning

Method 3: Exploration-based Learning

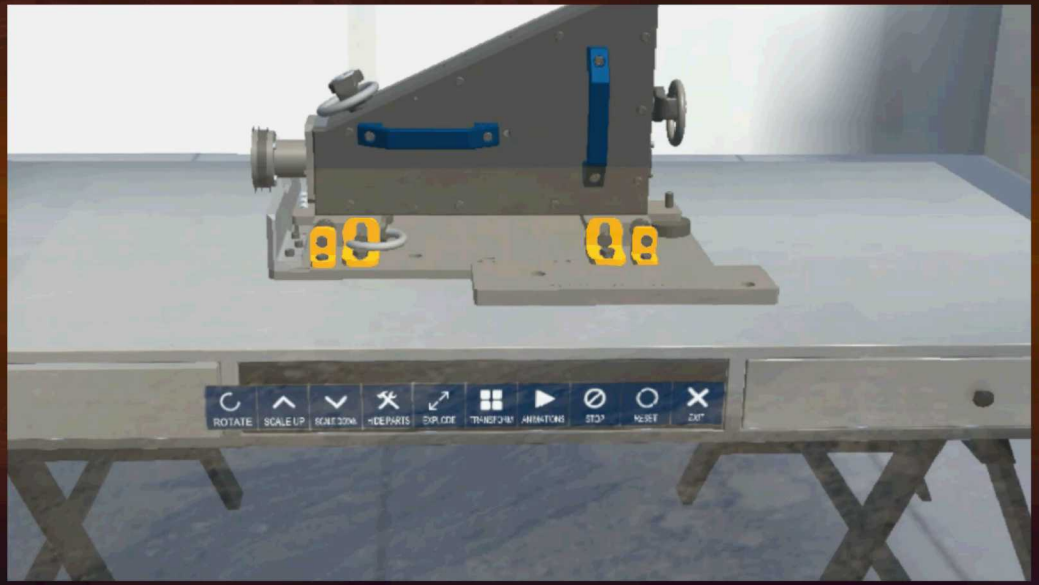
- Humans are born exploration-based learners
- By engaging the senses, humans engage their natural curiosity and form brain pathways based on their experiences
- XR Exploration-based training systems can create compelling, interactive, sensory-engaged learning experiences
- Increasing difficulty levels can provide exhilarating, fulfilling and more memorable learning experiences

Method 3: ARexplore Framework for Model Exploration

- Framework provides participants with design interaction mechanisms such as scale, explode, zoom, hide, and cutaway.
- Participants interact with models and designs via intuitive menus, gestures, voice commands, and receive audio and visual feedback

Voice commands:
- Scale Up/Down
- Zoom In/Out
- Explode View
- Select Object
- Hide Object
- Reset Scale
- Exit Application

CRITR Exploration AR Demonstration



Z-Team:
Brandon Klein,
Trent Yocom

AR Team:
Nadine Miner
Alexis Rubin

SAND No.
SAND2019-14385 O

Future Work

- **Sequential Training**
  - Several teams are developing custom frameworks and/or evaluating COTS frameworks
  - Collaboration is crucial to make efficient progress as a community, and to minimize repetition of effort
- **Real-World Facility Training**
  - There is much untapped potential in this domain
  - The Augmentations can include triggering sequential training and/or free form exploration, in addition to "standard" augmentations
- **ARexplore development is on-going and being expanded**
  - Ideal for collaboration and inner-sourcing this framework ac

Questions?

Nadine E. Miner, PhD

neminer@sandia.gov

Related Demonstrations

Training Type	Demo Area
Sequential Training w/target Recognition	XR@Z
Real-World Facility Training	Lab Inspector Walkthrough
Exploration-based Learning with ARexplore	XR@Z