Towards the Development of a VR-Based Emergency Response Scenario and Intelligent User Interface

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Research Team

Transforming education and training with next-generation learning technologies
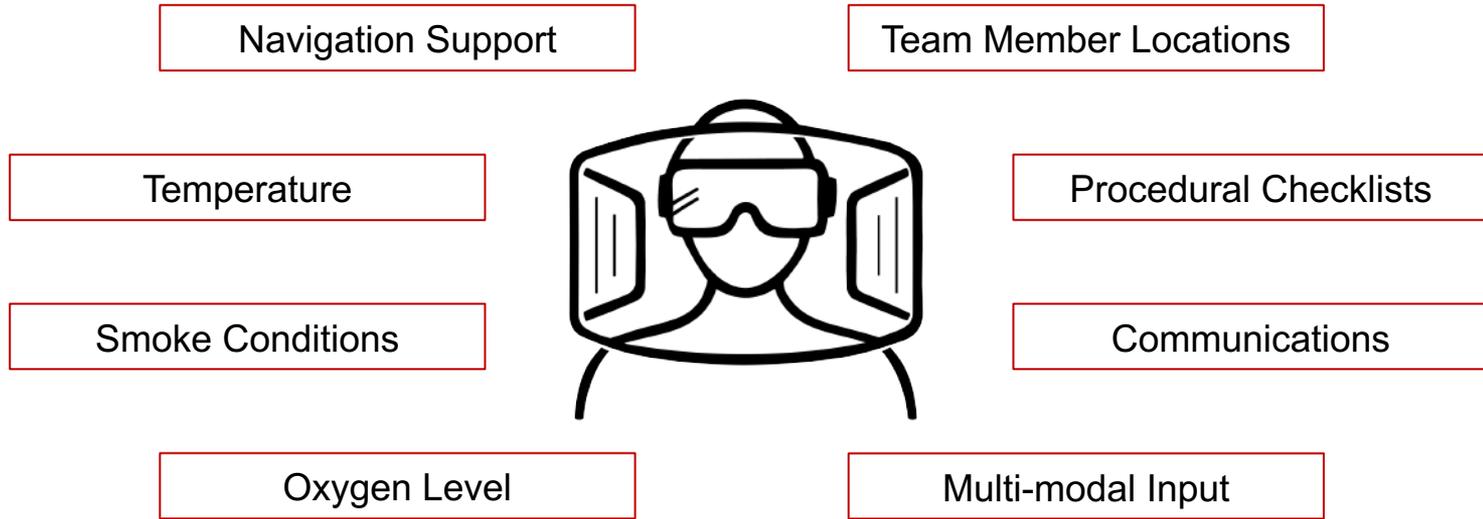

Independent, nonprofit research institute dedicated to improving the human condition

Washington Metropolitan Area Transit Authority

Next-Generation Heads-up Displays

Navigation Support

Team Member Locations

Temperature

Procedural Checklists

Smoke Conditions

Communications

Oxygen Level

Multi-modal Input

Guiding Research Question

How can interface designers ensure that first responders receive the right information, in the right format, and at the right time?

Key PSIAP-UI Hypothesis

We believe that **intelligent user interfaces** that adaptively present information customized to the need of individual users offer significant potential for improving task performance.

IUI Topics of Interest

- **Intelligent assistants** for complex tasks

- Interactive **machine learning**

- Modeling and **prediction** of user behavior

- **Multi-modal interfaces** (speech, gestures, eye gaze, face, physiological information, etc.)

- **Natural language** and speech processing

- Planning and **intent recognition** for IUI

- User modelling for Intelligent Interfaces

- **User-adaptive interaction** and personalization

Goals and Objectives

- **Goal 1**: Develop a VR emergency response scenario that will serve as a testbed for evaluating the impact of intelligent user interfaces on task performance.

- **Goal 2**: Investigate whether the intelligent user interface improves task performance and reduces cognitive load compared to a conventional interface.

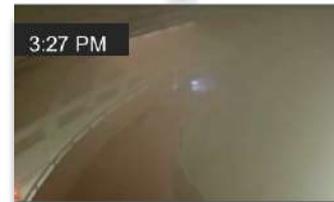# Year 1: AR/VR Technology Development

- VR scenario development
  - Develop with input from WMATA
  - Conduct site visits and interviews
  - Pilot testing with SMEs
- Intelligent user interface
  - Develop baseline model of interface
  - Collect corpus of training data
  - Machine learn goal recognition models
  - Integrate intelligent user interface into display
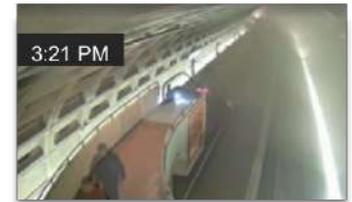
Year 2: Research and Evaluation

- Formal evaluation with WMATA and PSO stakeholders
  - Collect data from approximately 100 first responders
  - Intelligent user interface (n = 50)
  - Conventional user interface (n = 50)

- Determine whether the intelligent user interface leads to
  - Improved task performance
  - Reduced mental workload
  - Higher sense of presence
 - Improved usability

Overview

- VR scenario development

- Intelligent user interface development

- Plans for Year 2

Overview

- **VR scenario development**

- Intelligent user interface development

- Plans for Year 2

Iterative Design Approach

- Requirements gathering
- Gather input from stakeholders
- Design specifications
- Develop baseline
- Evaluate
- Refine design
- Develop new builds
- Evaluate
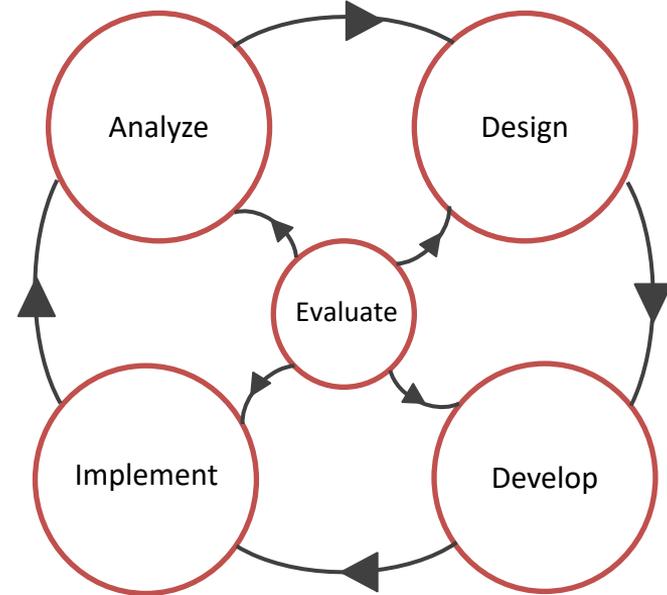
Requirements Gathering

- Reviewed
  - Incident reports associated with recent metro accident
  - Metro Incident Standard Operating Procedures
  - Metro Emergency Guides

- Outcomes
  - Identified critical elements to include the VR metro scenario
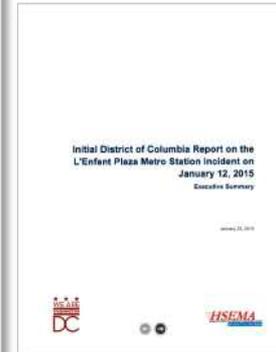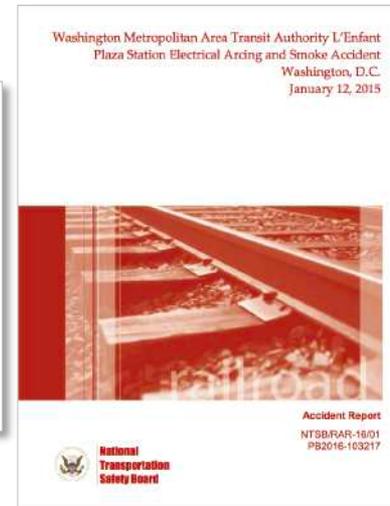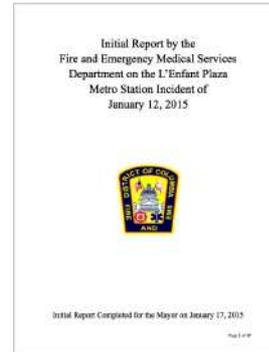
WMATA Site Visit

WMATA Emergency Response Training Facility

Objectives and Outcomes

- Met with the Director of Training of the Office of Emergency Management

- Reviewed partnership and goals of the grant

- Discussed strategies for recruiting Metro firefighters for interviews, pilot testing, and data collection events

- Identified upcoming training events to attend

VR Metro Environment (Baseline)

Features

- Analogue representation of DC metro station built in Unity

- Metro train, mezzanine, tunnels

- Interactive assets

- Controllers for smoke effects and locomotion

Focus Groups at WMATA

- Participants
  - 8 fire fighters from Montgomery County Engine 19 Company
- Procedure
  - Informed consent
  - Mission briefing
  - Completed three tasks in the Baseline VR Metro Enviroment
  - Responded to interview questions

Focus Group Outcomes

- Gathered critical feedback to improve the **physical** and **psychological fidelity** of the VR environment.
    - Locomotion, rail car design, station design

- Identified prioritized list of features to include in HUD
    - Oxygen remaining, navigation, radio chatter, team member location, vitals

Equipment Training Observation

Warning Strobe and Alarm Device (WSAD)

Tunnel Evacuation Carts

Equipment Training Observation

Turnout Gear

Thermal Imaging Camera

SCBA HUD

Scenario-based Training Observation

Emergency Response Training Facility

Search and Rescue Scenario

Scenario-based Training Observation

Training Observation Outcomes

- Learned tactics, techniques, and procedures for responding to metro emergencies

- Identified communication challenges

- Identified equipment challenges

- Gathering information on team roles and expectations

- Identified tasks to include in the VR scenario

Refined VR Metro Environment

Features

- Improved physical and psychological fidelity

- Embedded tutorial and briefing scenes

- 3 search and rescue mission scenarios

- HUD with scenario-driven data visualization panels

- Secondary radio monitoring task
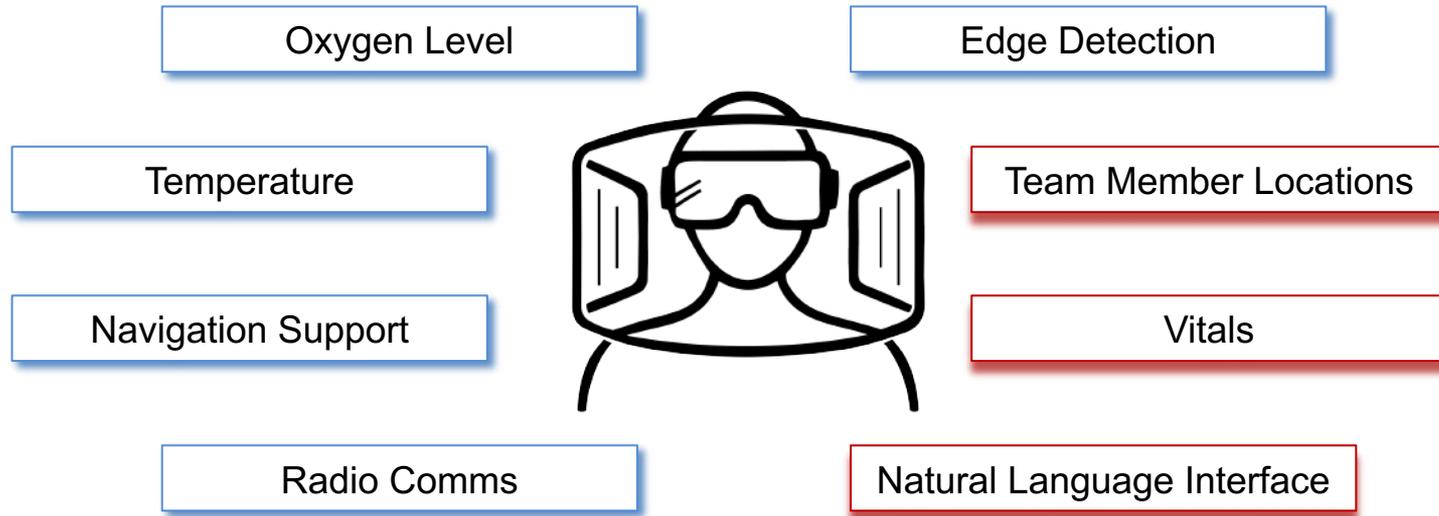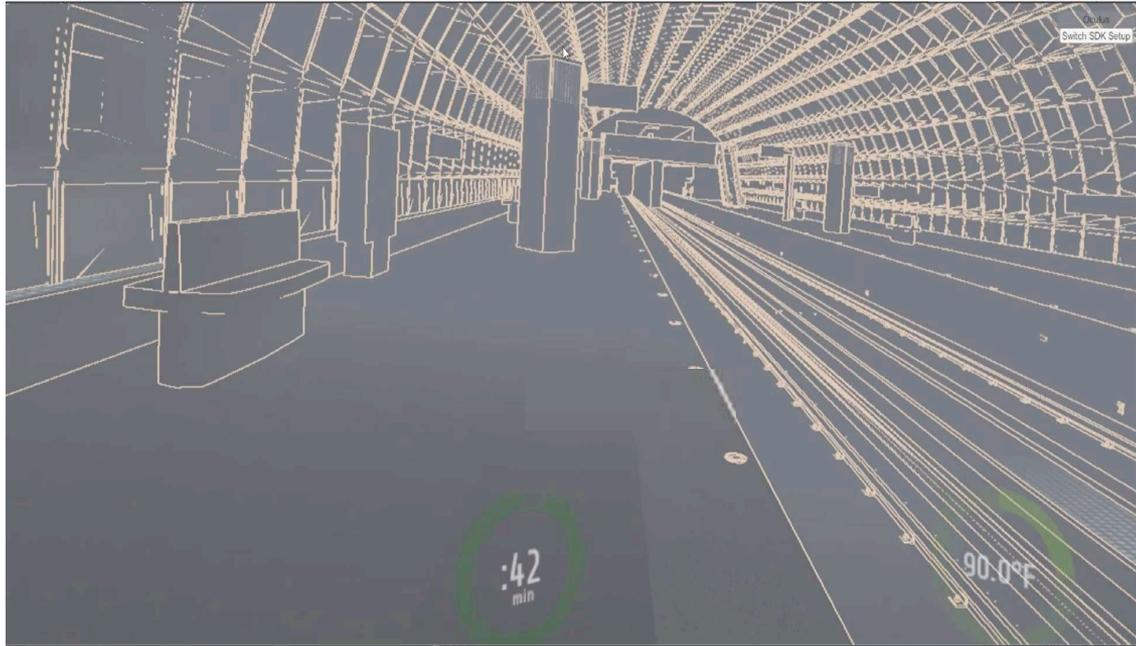
- AAR performance statistics
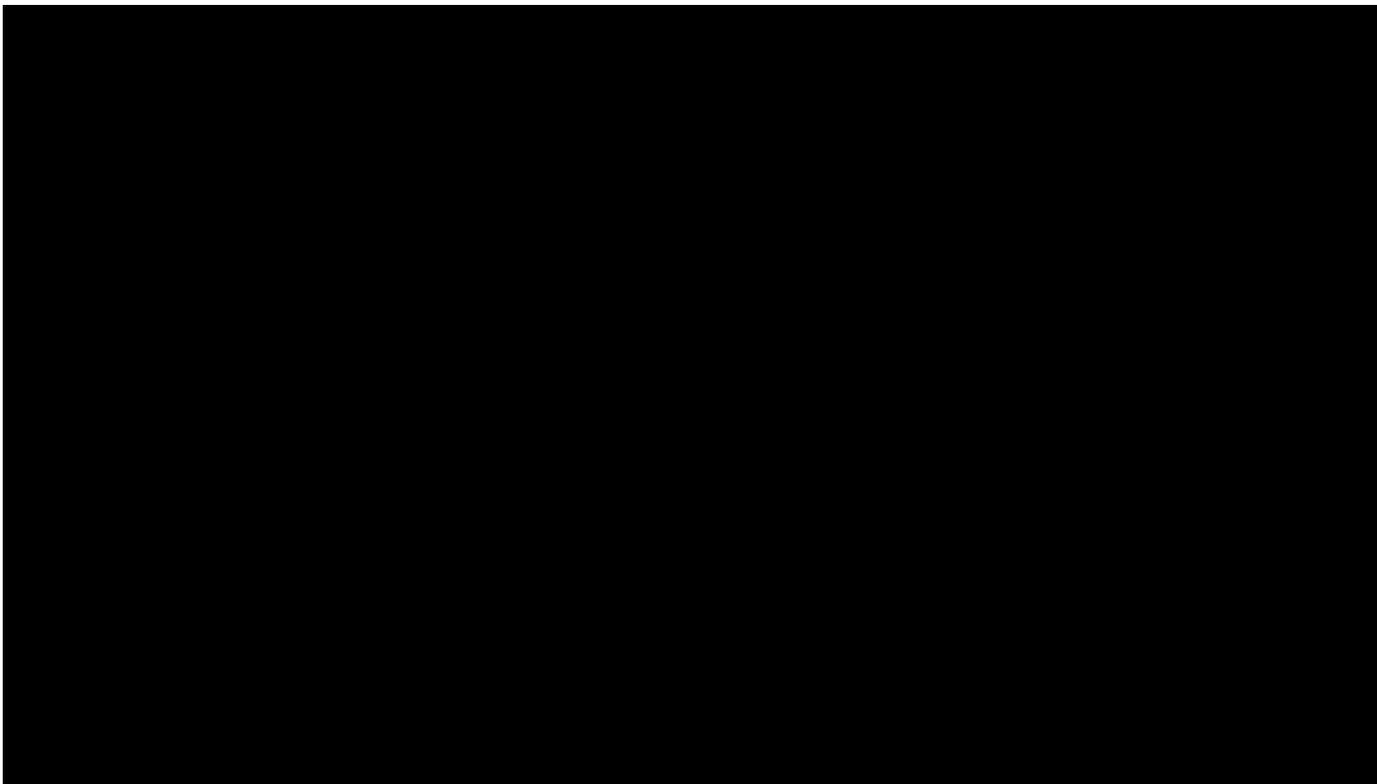
Overview

- VR scenario development

- **Intelligent user interface development**
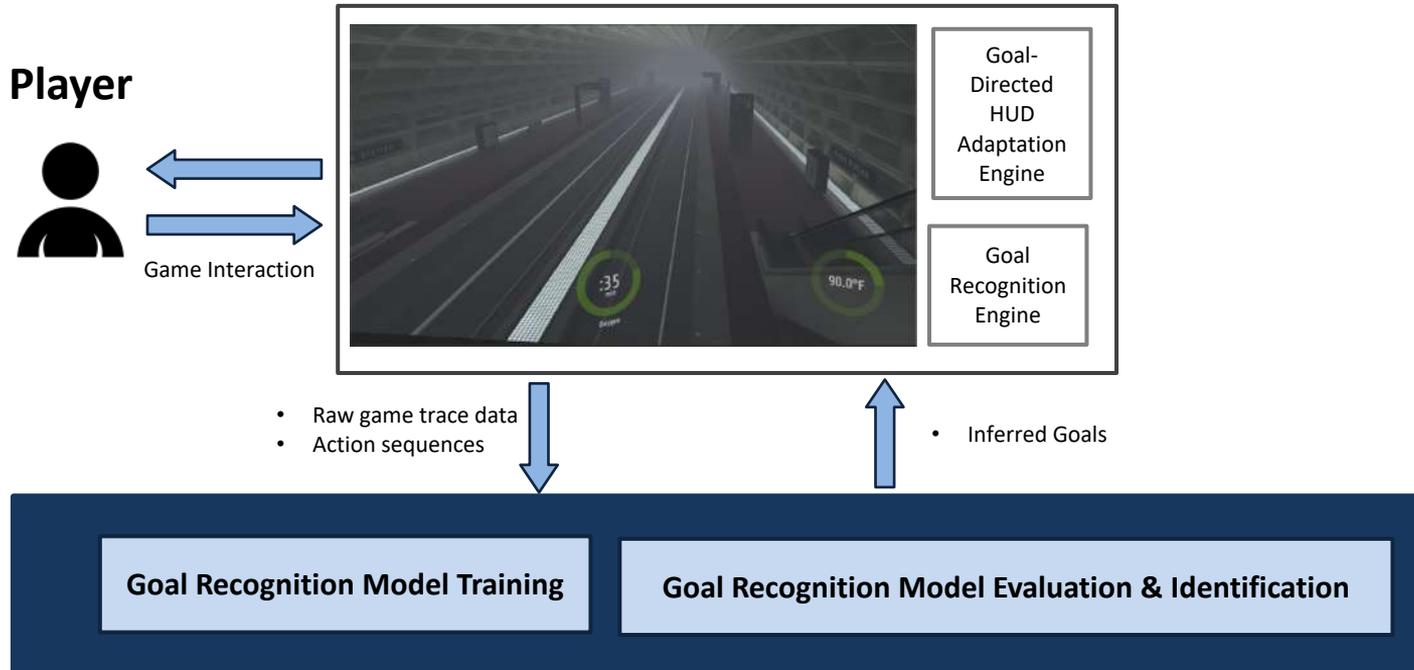
- Plans for Year 2

IUI Features

IUI Development Activities

- Integrating automatic speech recognition engine into software

  – Speech interface

- Adding gesture-based input

  – Control interface elements with gestures

- Investigate goal recognition capabilities of IUI

  – Present users with pertinent information based on mission-driven requirements

Goal Recognition Framework

Overview

- VR scenario development

- Intelligent user interface development

- **Plans for Year 2**

Research Questions

- Can the IUI improve task performance compared to a conventional display?

- Can the IUI reduce working memory load and improve task performance when participants are engaged in a secondary radio communication processing task?

- Does the IUI support first responders' situational awareness?

- How usable is the IUI?

Lab Studies

- Purpose:
  - Collect a corpus of training data that can be used to bootstrap development of IUI's
  - Refine experimental procedures
  - Pilot test instruments
  - Refine scenarios

- Timeline
  - Internal pilot testing (Summer 2019)
  - Data collection with students (Fall 2019 – Spring 2020)

Formal Evaluations with WMATA

- Purpose
  - Collect data from approximately 100 first responders to investigate benefits of IUI
  - Intelligent user interface (n = 50)
  - Conventional user interface (n = 50)

- Milestones
  - Conduct site with Durham Fire Department (Summer 2019)
  - Align data collection support from Durham and WMATA
  - Conduct formal IUI evaluation studies (Fall 2019 – Winter 2020)
  - Analyze data
  - Report findings

Potential Impact

- Foundational knowledge of how intelligent user interfaces should be designed to benefit first responders

- Guidance on how to design intelligent displays to

  - Reduce mental workload

  - Improve usability

  - Improve task performance

Summary of Upcoming Milestones

Near-term Tasks

- Integrate ASR into HUD
- Refine metro enviroment
- Finalize metro scenario tasks
- Integrate additional HUD data sources
- Collect training data

Upcoming Events

- Lab testing (August 19)
- HFES demo (October 19)
- Data collection with students (Fall '19 – Spring '20)
- WMATA data collection (Fall '19)

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Department

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