



# U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – SOLDIER CENTER

Enhancing AR with Quantitative VR Human Performance Data Serious Gaming and Virtual Reality HFE VTAG

Aaron Gardony, Ph.D.

Cognitive Scientist

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited. PAO: PR2021\_90075

U.S Army DEVCOM Soldier Center, Soldier Effectiveness Directorate, Performance Division, Cognitive Science and Applications Team

Work Package Lead – Soldier Optimized Augmented Reality for Enhanced Tactical Decision Making

Measuring and Advancing Soldier Tactical Readiness and Effectiveness (MASTR-E) Program

29 JUN 2021

APPROVED FOR PUBLIC RELEASE



# MILGRAM'S REALITY-VIRTUALITY CONTINUUM





Image Source: https://www.canterbury.ac.nz/hitlab/research/

APPROVED FOR PUBLIC RELEASE



# HUMAN-CENTERED SOLDIER AUGMENTED REALITY



Done right, AR offers transformative capabilities



#### Done wrong, AR can harm human performance



# HUMAN-CENTERED SOLDIER AUGMENTED REALITY







# SOLDIER XR TECHNOLOGY: PROMISES AND CHALLENGES



- The modern multi-domain battlefield will present Soldiers with significant quantities of complex and rapidly changing information – more than ever before
- Augmented Reality (AR) systems, like the IVAS, are being developed, in part, to address this challenge by providing hands-free, heads-up contextual information that can:
  - Improve situational awareness (SA)
  - Minimize cognitive load
  - Enhance lethality
- However, if designed improperly AR can harm human performance
- Moreover, R&D challenges abound...
  - AR hype vs. technological matration
  - Underlying technology is advancing rapidly
  - AR hardware/software development takes time and money
  - Emerging capabilities can be transformative or not- it's hard to know without testing them out



Image Source: https://www.rand.org/blog/2017/09/artificial-intelligence-and-the-military.html





# SIMULATING AR IN VR



- Simulating AR in VR enables researchers to:
  - Select and control simulated AR hardware and software features
  - Simulate realistic and Soldier-relevant tasks
  - Collect rich quantitative human performance measures
- Quantitative data can help assess the human performance impacts of emerging AR capabilities and provide data-driven design recommendations to technology developers and stakeholders.



Image Source: Center for Applied Brain and Cognitive Sciences





# HUMAN-CENTERED AUGMENTED REALITY



#### Inform System Requirements



#### Monitor User Attention & Status



#### **Enhance User Experience**





# **HUMAN-CENTERED AUGMENTED REALITY**



#### Inform System Requirements



#### Monitor User Attention & Status



Enable Optimized and Intuitive Soldier AR Systems



#### Enhance User Experience





#### **GAZE-ENHANCED AUGMENTED REALITY (GEAR)**



Done right, AR offers transformative capabilities







SITUATIONAL MOVING & AWARENESS NAVIGATING

FING PLANNING

SHOOTING

SEEING

Done wrong, AR can harm human performance



How do we realize AR displays (and other Soldier technologies) that maximize human performance?

Real-time robust eye tracking will enable this for AR and for future technologies





#### GAZE-ENHANCED AR

- Soldier AR systems have multiple integrated capabilities
- How can a Soldier control them all quickly and effectively?
- Actively Control AR interfaces with Gaze
  - Through gaze alone (dwell-time based)
  - Through multimodal input combinations
- Intuitive but see: "Midas Touch"<sup>1</sup>
- Simulating and Evaluating gaze-triggered AR HUDs in VR







Enhancing UX

Immersive VR

APPROVED FOR PUBLIC RELEASE

#### **GAZE-ENHANCED AR**



Gaze-Contingent Interfaces Gaze Location Gaze Location 1-Stage (1S) Dwell-Based 2-Stage (2S) Dwell-Based Shooting the Wrong Target Workload 45 50 **Average Number of Hits** 40 40 40 X**TL-BSAN** 30 30 20 10 0 25 Always On **1S 2S** Always On 1S 2S Deliver: Data-driven technical recommendations for gaze-based AR input



APPROVED FOR PUBLIC RELEASE



#### **GAZE-ENHANCED AR – FUTURE DIRECTIONS**



- Gaze depth as a secondary input
  - Lu & Bowman's (2021) Head Glance Plus (HG+) Interfaces<sup>2</sup>
  - Require correct gaze direction, *gaze depth*, and optionally dwell







# **AIDED TARGET RECOGNITION (AITR)**



- Soldier AiTR AR systems are being developed with the intent to highlight areas of interests (ex. potential threats) to facilitate target acquisition.
- Visual appearance of AiTR could adversely impacting visual attention by:
  - Increasing visual clutter
  - Aggressively capturing attention & decreasing SA
- Emerging research suggests "soft highlighting" may ameliorate SA deficits to secondary (i.e. uncued) targets and reduce visual clutter.<sup>3,4</sup>





# AIDED TARGET RECOGNITION (AITR) - VR SCENARIO



- Shoot/Don't Shoot decisions at Entry Control Point (ECP)
  - Based on camouflage pattern
- Secondary window civilian observe and report task
- Bounding Box and Soft Highlights, false alarm highlights to NPCs
- Real-time eye tracking and behavioral response logging









#### <sup>2</sup>Kneusel & Mozer (2017), <sup>3</sup>Larkin et al., 2020

Secondary civilian target

APPROVED FOR PUBLIC RELEASE



# AIDED TARGET RECOGNITION (AITR) – DEMO VIDEO





Dwell time (Secondary): 1.1 sec



# **CURRENT XR OPPORTUNITIES AND GAPS**



#### **Opportunity: Eye-Tracking**

- High accuracy (<1-2°)
- Increasingly bundled with commercial XR HMDs alongside SDKs
- Access to raw gaze data / eye images can be difficult/impossible (consider ML)
- SDKs require custom-coded solutions (but see: OpenXR)
- Accuracy may be at ceiling (at least for commercial HMDs) due to market forces

#### **Opportunity: Weapon Operations Simulation**

- Currently can mimic weapon operation with some functional fidelity
- Proper weight, recoil, sight picture with HMD remain challenging

#### **Opportunity: Navigation Simulation**

- Land navigation key application of VR
- VR sickness remains a concern
- Ultra low-latency VR treadmills are promising



Image Credit: https://www.vrfitnessinsider.com/





Image Credit: https://www.protubevr.com





#### • Simulating AR capabilities in VR:

- Offers excellent experimental control
- Permits testing of novel and emerging capabilities
- Lowers evaluation cost and time, enabling Soldier-centered design

#### Human-Centered XR can:

- Enhance Soldier performance during training and operations
- Minimize cognitive burden
- Improve user experience
- We are building a community across the DoD to develop and research human-centered XR systems.

# Army researchers establish mixed reality working group

X U.S. ARMY

By CCDC Soldier Center Public Affairs June 26, 2020





https://www.army.mil/article/236779/army\_researchers\_ establish\_mixed\_reality\_working\_group







Questions?

- [1] Jacob, R. J. (1991). The use of eye movements in human-computer interaction techniques: what you look at is what you get. ACM Transactions on Information Systems (TOIS), 9(2), 152-169.
- [2] Kneusel, R. T., & Mozer, M. C. (2017). Improving human-machine cooperative visual search with soft highlighting. ACM Transactions on Applied Perception (TAP), 15(1), 3.4
- [3] Larkin, G. B., Geuss, M., Yu, A., Rexwinkle, J., Callahan-Flintoft, C., Bakdash, J., ... & Lance, B. (2019). EMERGING RECOMMENDATIONS FOR INITIAL AUTOMATED TARGET RECOGNITION (ATR) DISPLAY CONSIDERATIONS: Implications for Concept Development and Evaluation.
- [4] Lu, F., & Bowman, D. A. (2021, March). Evaluating the potential of Glanceable AR interfaces for authentic everyday uses. In 2021 IEEE Virtual Reality and 3D User Interfaces (VR) (pp. 768-777). IEEE.

Disclaimer: The views expressed in this article are solely those of the authors and do not necessarily reflect the official policy or views of the Department of the Army, Department of Defense, or the United States Government.