Using virtual reality to simulate wilderness search and rescue clue-finding tasks

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Introduction

Prior work: Open-terrain simulation of search and rescue task.

- Heavy burden on the research team with equipment, personnel, space, training, and coordination investment.
- Limited by terrain and cases in which data can be safely collected.

Current investigation seeks to establish virtual reality (VR) as a feasible complement.

- Tighter experimental control/manipulation, 3D interactive environments, and varied real-world target categories that capture wilderness search and rescue scenarios
- Assess metrics of target visibility including distance from viewer to target (radius) and mean square error (MSE) between an environment with and without the target
  - MSE is a conventional metric for assessing image compression.

Method

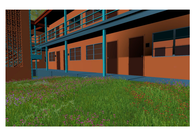
Environment Design: The virtual environment was modeled in Unity3D after the courtyard of a NMSU residence hall, the site of a physical variation of the experiment (Penn & Hout, 2020).

Penn & Hout, 2020:

Environment

Target

VR Derivative:



Environment

Target

Trial Mechanics:

- Objects were placed in random positions within the search area at the start of each trial.
- Trials ended when the participant located the object by pointing the controller and clicking a button.

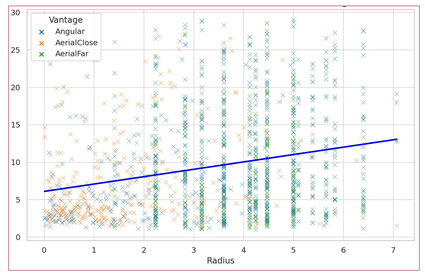
Experiment Structure:

5 min break

Practice	Block 1	Block 2
•4 trials. 2 min. •30 seconds / trial.	•26 trials. 13 min •30 seconds / trial.	•26 trials. 13 min. •30 seconds / trial.

Results

- **Factors:**
  - **Radius:** Distance between player and object.
  - **MSE:** A measure of average squared difference between pixel values of two images, quantifying their dissimilarity.
  - **Response time (RT):** Time to locate object in each trial.
  - **Vantage:** The perspective from which the object was captured.
- **We used a linear mixed model analysis with the three factors predicting RT. The model included all main effects and interactions.**
- **We used a logistic regression with the same factors to predict the probability of target detection failures (trial timeouts).**

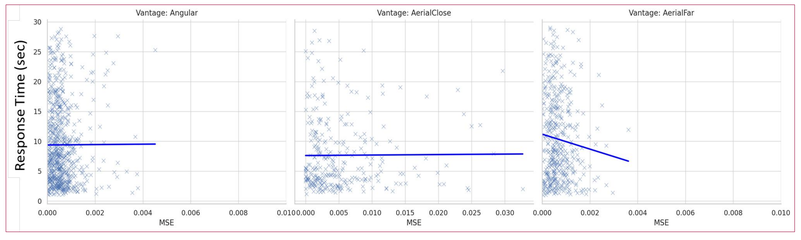


Response Time Results

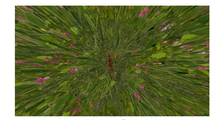
R^2 = .11

Radius: F(1,1500)=20.498,p<. 001

MSE × Vantage: F(2,1504)=3.891,p=.021



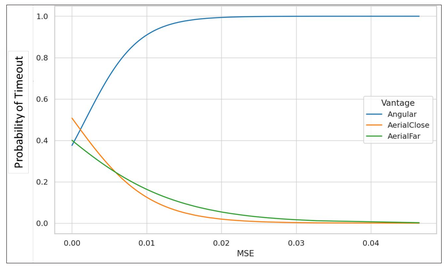
Vantage Points:

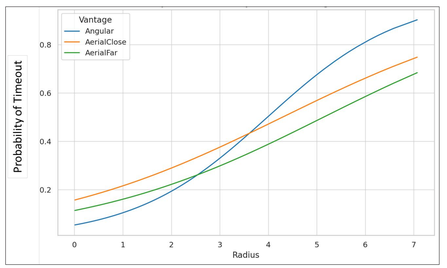


AerialFar

Angular

AerialClose





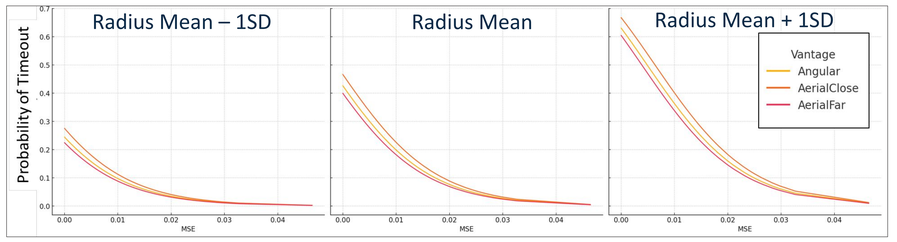
Likelihood of Target Detection Failure Results

Radius: β=0.511,OR=1.666

MSE: β=-166.044,OR=7.72e-73

Angular-AerialClose: β=-0.554,OR=0.575

MSE * (Angular-AerialClose): β=415.818,OR=3.87e+180



Conclusions

- **MSE (Visibility):** Targets with higher visibility (higher MSE) are less likely to result in target misses, reinforcing its validity as a visibility metric in VR environments. However, MSE alone did not significantly predict RTs.
- **Radius (Distance):** Larger distances consistently increase both timeout likelihood and RTs.
- **Vantage:** AerialFar was associated with reduced likelihood of missing targets compared to other vantage points, particularly at higher MSE values and shorter distances.

Future Directions

- **Adjusting visibility metrics**, particularly Angular and AerialClose, to better account for response time.
  - Validate metric by showing captures to separate set of participants and rating similarity.
- **Adding measurements:** While video data from the trials can show if participants turned around, for example, could be added as a metric.
  - Potential branching into Structured Similarity Indexing Method and Feature Similarity Indexing Method, which are more grounded in perception (Sara et al., 2019).