Comparing Situation Awareness for Two UAV Human Interface Approaches

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Specific problem

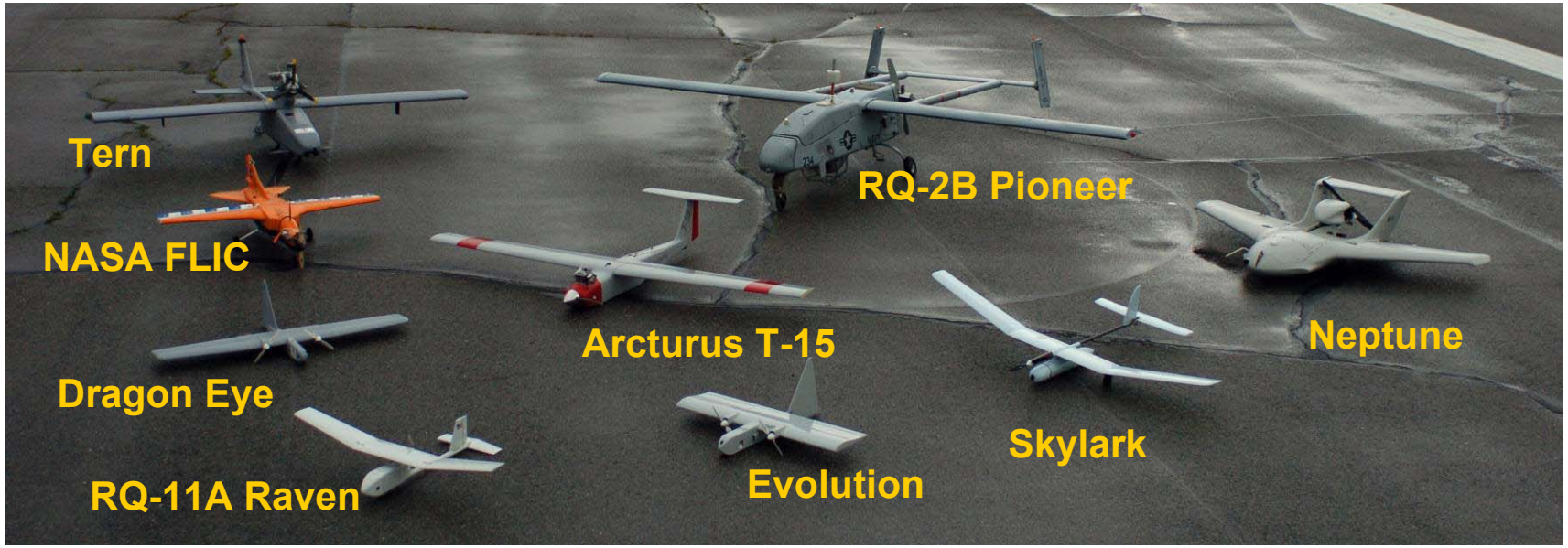
- UAV video is extremely important
- But how to eliminate the feeling that operators are looking through a "soda straw"?

Photo: Global Hawk, DoD photo no. 980228-D-0000M-002

"It's like driving your car with paper towel tubes over your eyes…"

Overall research objectives*

- Develop and evaluate interaction designs that support small teams operating multiple UAVs simultaneously
- Implement “awareness mechanisms” to allow distributed team members to better understand each others’ activities
- Generalize our understanding of what can improve situation awareness to other domains



DoD photo no. 050627-N-0295M-021

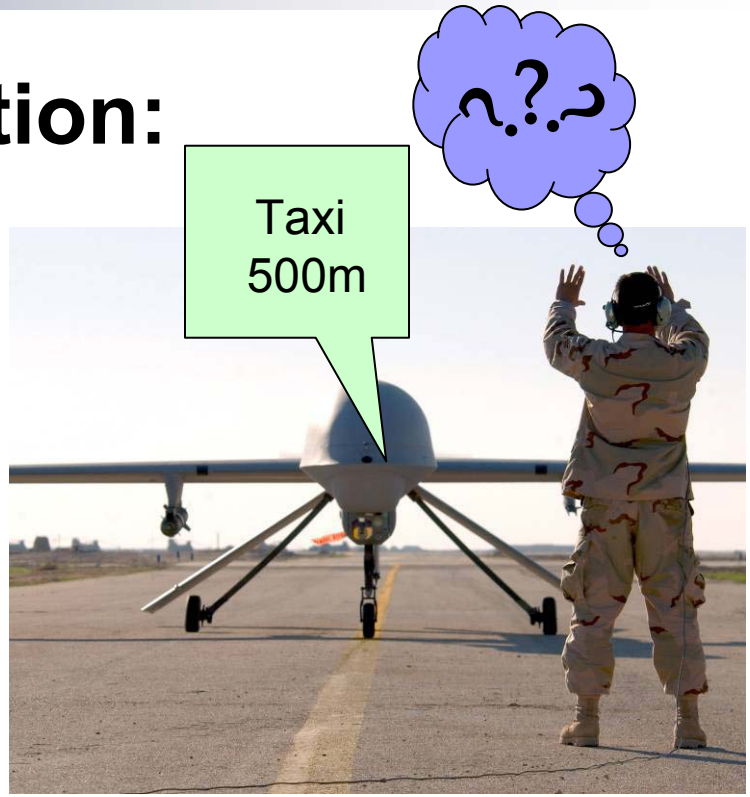
*for MITRE team members

Looking closer at Situation Awareness

- Situation Awareness (SA) defined originally in Air Traffic Control domain by Endsley (1988):
  1. The perception of the elements in the environment within a volume of time and space
  2. The comprehension of their meaning
  3. The projection of their status in the near future
- *But*, Air Traffic Control ≠ Airborne Robot Control

Endsley's definition assumes…	…but the UAV domain differs…
The human is the only intelligent entity needing information	UAVs need information about the environment, other UAVs and humans' directives--they are team members!
Team members are peers	UAVs are fundamentally different from human team members, and will thus respond differently

The UAV SA decomposition: Portion of base case



- Given one human and one UAV working together, human-UAV interaction awareness consists of the understanding that the human has of the:
  - 3D spatial relationship between…
    - UAV and points on the earth
    - UAV and terrain
    - UAV and other aircraft
    - UAV and targets
  - Predicted 3D spatial relationships
  - Weather near the UAV
  - Health of the UAV
  - (Non-health) status of the UAV
  - Logic of the UAV
  - Operational threats
  - UAV's mission
  - UAV's progress towards completing the mission
  - Degree to which the UAV can be trusted

Source: Drury, Riek, and Rackliffe (2006). A Decomposition of UAV-Related Situation Awareness. Proceedings of HRI 2006 Conference.

Designed 3D interface

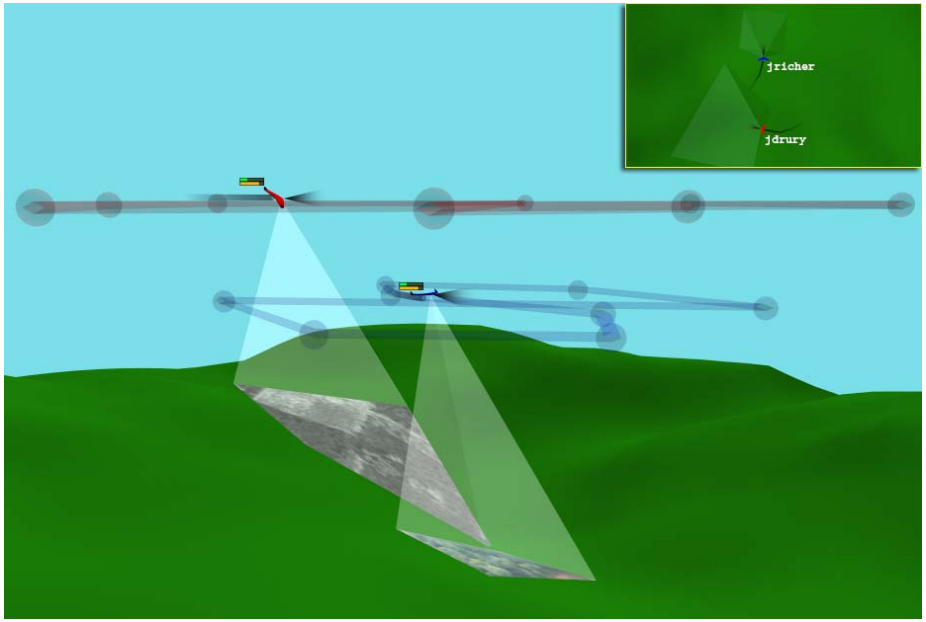
Related work

- Drascic and Milgram (1996) did early work on "augmented virtuality"
- Cooper and Goodrich (2006) developed an augmented virtuality interface for a small handheld controller
- Nielsen et al. (2005) and Ricks et al. (2004) explored the use of augmented virtuality
- Quigley et al. (2004) used a "chase plane" perspective to control the UAV on a PDA
- Calhoun et al. (2005) explored a "picture in picture" approach

Our work differs in that we incorporate 3D navigation and integrate path planning with augmented video

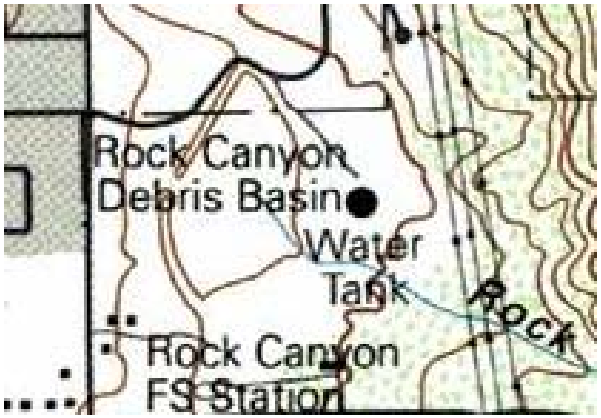
More on our prototype design

- "Augmented Virtuality" interface design integrates route planning with wider virtual field of view
- Exocentric view of aircraft avatar with projection of video georeferenced onto pre-loaded terrain background

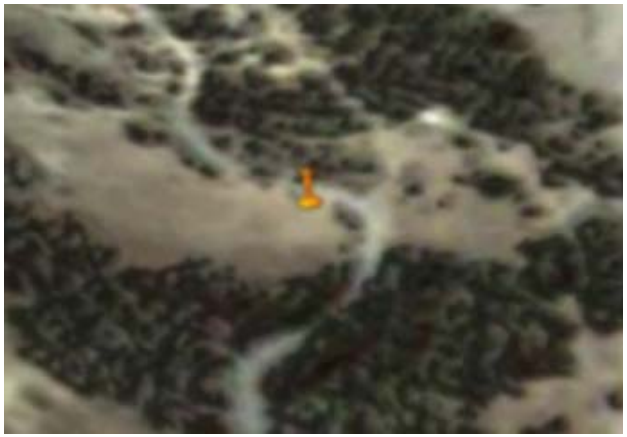


Hypothesis: seeing aircraft avatar and video projected onto map data will provide operators with better comprehension of 3D spatial relationships between UAV and points on the earth than if they see unaugmented video

Experiment overview

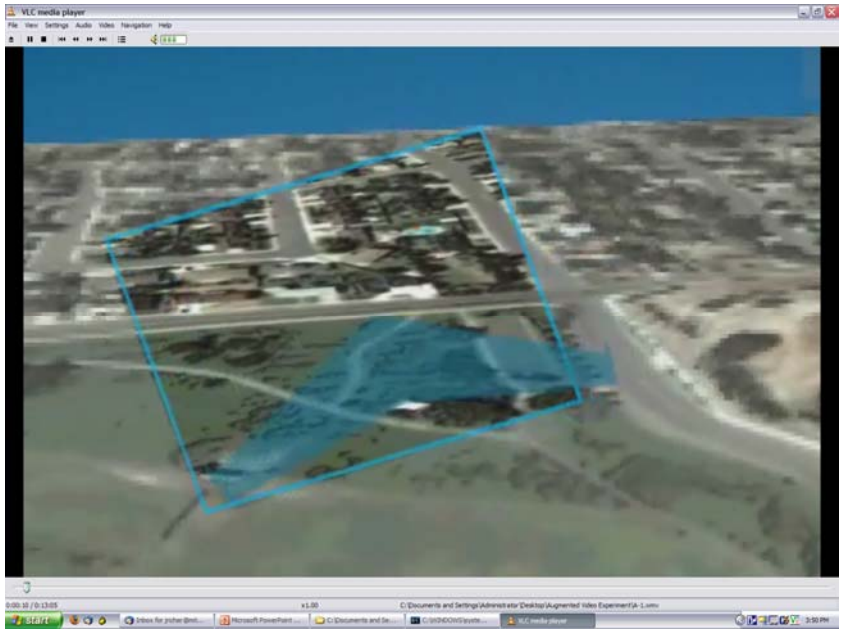


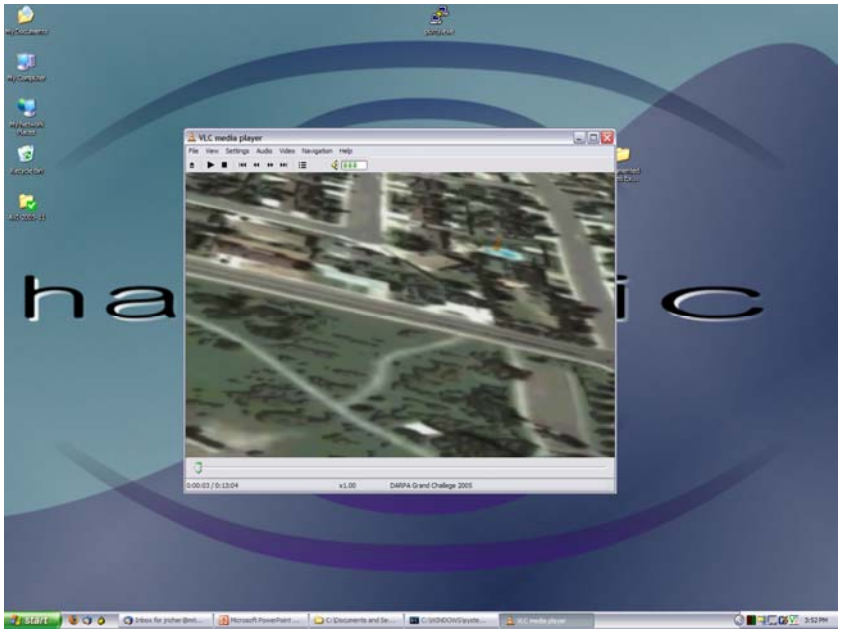
Map fragment and example snapshot of a lost hunter



- **Within-subject; each participant used both interfaces**
- **Performed a search task for lost hunters**
- **Marked hunter positions on paper topographical maps**
- **Measured differences in mapping accuracy**

Experiment set-up





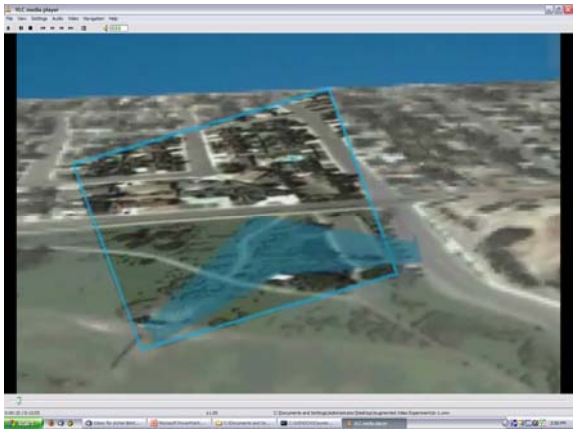
Our augmented video design …versus ... plain video

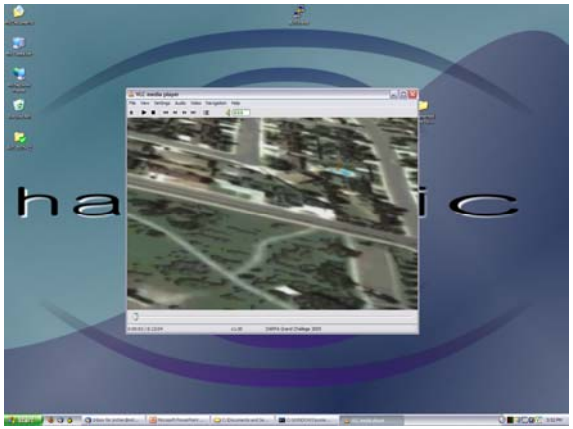
Passive search task only, so interfaces presented as movies

Experiment participants

- 12 people from high-tech company
- All rank their computer literacy as at least moderate
- 7 men, 5 women
- Wide range of ages (20s to 60s)
- 6 had no previous experience with robots, 6 had minimal experience (robotic toys)
- 6 had used remote controlled aircraft or cars (toys)
- 8 play video games at least occasionally
- 1 was a sailplane pilot 20 years ago and 1 is a pilot of ultralight and powered paraglider aircraft

Experiment procedure





- Welcome and explanation
- Demographic questionnaire
- Training on first interface
- Task using first interface
- Post-run questionnaire
- Training on second interface
- Task using second interface
- Post-run questionnaire
- Post-experiment questionnaire
- Thanks, and answering any of participant's questions

Data collection and measures

- Paper maps with marked hunters
  - Differences between ground truth and marked positions
  - Number of missed hunters
  - Number of duplicate marks for same hunter
- Post-run and post-experiment Likert scale questions
  - Understanding of UAV's location with respect to the ground
  - How well interface helped to perform the search task
  - Preference of interfaces
- Audio recordings
  - Captured degree of certainty regarding hunter positions, expressions of confusion, etc.

Mitigated possible confounders

- Compared differences in distance between subject-drawn and truth positions to factor out individual mapping abilities
- Simulated video with pre-recorded search patterns so that they were replicated exactly each time
- Provided two patterns of lost hunters of equivalent difficulty so no learning effect from first to second run
- Counterbalanced interface order and hunter pattern order
- Pre-screened for color blindness
- Pre-scripted introduction and training

Experiment results

Result	Video only	AVI	Significance of difference*
Average error between marked and truth positions for victims	66 mm	54 mm	$p < .05$
Likert scale response when asked if they had a good understanding of the UAV's location with respect to the ground	2.7/7	3.9/7	$p < .003$
Likert scale response when asked if interface helped to perform the search task	3.0/7	3.9/7	$p < .003$
Likert scale response when asked for interface preference	2.2/7	5.8/7	$p < .003$

No statistical significance in differences in missed or duplicate hunters

***Significance calculated using paired, 2-tailed t-test with dof = 11**

Comments from participants

- Some thought the video was presented slower in the augmented interface
- Others commented directly on the enlarged field of view:
  - "it's easier to recognize where the UAV is relative to the entire search space"
  - "it was distracting at first but definitely helped orient me"
- Positive feedback on avatar:
  - "seeing attitude of the plane was useful"

USAF photo

Conclusions

- Experiment showed that providing contextual information via pre-loaded terrain data plus a transparent avatar in a “chase plane” view aids SA
- Results appear promising for map-based search tasks (beyond UAVs)