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## **1. Honor Code**

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I pledge on my honor that I have neither given nor received unauthorized aid on this assignment.

Note: Large portions of this initial description are copied and adapted from NASA Grant #NNX13AL65H; this project is a portion of and described extensively in the grant.

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## **2. Hypothesis**

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1. Participants will be able to formulate answers to situational awareness probes more quickly when the Robot Visualization Abstraction Algorithm (RVAA) is used compared to when a baseline visualization strategy is used
2. Participants will be able to formulate answers to situational awareness probes more accurately when the Robot Visualization Abstraction Algorithm (RVAA) is used compared to when a baseline visualization strategy is used
3. Participants will have better situational understanding at the end of formal testing when the Robot Visualization Abstraction Algorithm (RVAA) is used compared to when a baseline visualization strategy is used
4. Participants will prefer the RVAA as a visualization strategy over the baseline visualization strategy

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## **3. Evaluation Participants**

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A total of 12 participants will be recruited from the graduate and undergraduate students available in the area during the testing period. The selection criteria include the following:

- Lack of knowledge of and experience with the RVAA and its superset, the System of Human-Robot Interfaces (SHRI).
- Normal or corrected-to-normal color vision.
- Normal dexterity with at least one hand, either right or left, adequate for using a mouse cursor positioning device.
- No specific gender or age requirement.
- Willingness and enthusiasm to freely give opinions about good and bad features of the software being used and tasks being performed.

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## **4. Experimental Design**

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The design of the experiment is a within-subjects and counter-balanced design.

### **Independent Variable**

- Absence or presence of the RVAA to control the display of robots on the map

### **Dependent Variables**

- Quantitative measures:
  - The amount of time it takes a participant to answer questions regarding events on the map and the actions of the robots. This will be an objective measure.
  - The accuracy of a participant when answering questions regarding events on the map and the actions of the robots. This will be an objective measure.
  - The participants' understanding of the overall situation after the end of the formal testing, possibly through the use of mouse-over and hover events. This will be an objective measure.
  - The participants' preference for the visualization strategy of the robots. This will be a subjective measure.
- Qualitative measures:
  - The participants' reasoning and justifications for their preference of visualization strategy of the robots. This is a subjective measure.

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## **5. Data collection and Recording**

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All questionnaires are derived from previous studies of the SHRI.

### **Sources of data**

- Background demographic questionnaires
- Situational Awareness questionnaires
- Administrator recording of time and accuracy rates
- Subjective Comparison of Demand Factors survey

### **Data topics**

- Ratings of various situational awareness dimensions
- Preference for robot visualization strategy
- Time taken to answer questions regarding situational understanding
- Accuracy of answers regarding situational understanding

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## **6. Data Analysis**

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### **Purpose**

- The purpose of quantitative data analysis is to determine the amount of time required to answer situational awareness probes, as well as the accuracy and understanding with which they do so. The resultant preference for robot visualization strategy will also be determined. Given that this is intended to be a pilot study with a small group of participants, it will be difficult to apply parametric or non-parametric statistical analysis of variance with validity, but some descriptive statistics of central tendency will be appropriate.
- Qualitative data will be collected and analyzed for the purpose of improving future versions of the visualization strategy

## Activities

- Compile descriptive statistics of the quantitative data, including means, standard deviations, and quartiles, and graph the results
- Identify recurring themes and patterns in the qualitative data, discerning commonalities in which participants think the algorithm could be improved

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## 7. Scenario Scripts

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Italicized phrases indicate actions or instructions for the administrator.

All other non-header phrases are to be considered dialogue.

### 1. Introduction

Thank you for participating in this experiment. The main objective of this experiment is to study how a particular robot visualization strategy, the Robot Visualization Abstraction Algorithm, affects an operator's understanding of a situation. The study is not intended as a test of your personal ability. The entire study will require around 30 minutes without interruptions. Please switch your cell phone to silent or vibrate for the experiment.

### 2. Overview of the Experiment

The experiment will consist of three sessions, including training and formal testing. There are two trials in formal testing. You will first complete an informed consent form. Then you will be introduced to the Unmanned Vehicle Specialist (UVS) interface. The training presentation also includes information items (icons) that will appear on the interface and the tasks that you will be asked to observe during the formal testing.

The steps of the complete experimental procedure include:

- Completion of the informed consent form and training (4 mins)
- Formal Testing (20 mins)
- Completion of after-experiment questionnaires and experiment (6 mins)

### 3. Completion of the Informed Consent Form

Before we start the experiment, please read and sign this informed consent form. This form contains general information about the experiment, possible risks and benefits to participants. I encourage you to read the form in its entirety. If you have any questions, please feel free to let me know. Please sign and date the form when you are finished reading.

*{Prepare forms and a pen. Sign consent form.}*

### 4. The Demographic Survey

Please fill in this demographic survey form. Your personal information, including name, age, gender, etc. will not be used beyond this study.

*{Prepare demographic survey. Complete the demographic survey.}*

## **5. Training Presentation and Q&A**

This training presentation will give you an introduction to the UVS interface as well as the objects and tasks that you are going to be asked to identify during testing. If you have questions at any time during the presentation, please feel free to let me know.

*{Prepare and display training presentation.}*

## **6. Format Testing**

In the formal testing, you will observe and interpret the graphical representation of information and events as they are presented to an EMS UV Specialist. This will include icons for information items, objects, robots, and their tasks for both the HazMat team and the EMS team. The color of the task area represents the type of operator; your tasks will be yellow, HazMat tasks will be red, and police tasks will be blue. HazMat and police robots will be shown in half transparency.

During the testing, you will be asked questions about the situation periodically. Please answer the questions promptly. Before we begin the formal testing, do you have any questions?

*{Prepare the map and scenarios. Participants will be randomly selected to start with either the RVAA or the baseline visualization algorithm.}*

*{The first scenario for the participant will be started now. Record the participant's responses and response time during the evaluation. Mark the correctness based on the ongoing situation.}*

Thank you. We are about half done now. This trial will be similar to the first. Again, you will be asked questions about the situation periodically. Please answer the questions promptly.

*{The second scenario for the participant will be started now. Record the participant's responses and response time during the evaluation. Mark the correctness based on the ongoing situation.}*

## **7. After-Experiment Questionnaires**

You are now done with the formal testing. Please complete these next few questionnaires.

*{Prepare situation awareness, subjective demand, and preference questionnaires.}*

This first questionnaire measures your knowledge of the overall situation during the evaluation. The second questionnaire asks you questions about your overall experience with the system and robots. Please feel free to let me know if you have any questions.

*{Ensure that you can read any written responses. If the writing is questionable, please re-write.}*

## **8. Completion of Experiment**

Thank you for your time.

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## 8. Questionnaires

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### Demographic Survey

Age \_\_\_\_\_

Gender                      Female                      Male

Education                      High School                      Some College                      College Degree  
   Some Graduate School                      Masters                      Doctorate

Corrected-to-normal or normal vision                      Yes                      No

### Prior Experience

Experience with first response or disaster response incidents

- ☐ No experience
- ☐ Once
- ☐ More than once but less than ten times
- ☐ Frequently
- ☐ All the time

Tele-operate (e.g., remote control) a Robot

- ☐ No experience
- ☐ Once
- ☐ More than once but less than ten times
- ☐ Frequently
- ☐ All the time

Programmed a Robot

- ☐ No experience
- ☐ Once
- ☐ More than once but less than ten times
- ☐ Frequently
- ☐ All the time

Experience reading and understanding maps (physical, computerize, GPS-car style, etc)

- ☐ No experience
- ☐ Basic understanding
- ☐ Good understanding
- ☐ Complete understanding

### Prior Video Gaming Experience

Any Video Games

- ☐ Never played a video game
- ☐ Have played at least one game
- ☐ Have played more than one but less than ten times
- ☐ Have played a few games

- Play these games frequently

Real Time Strategy Games (e.g. Starcraft, Age of Empires, Etc)

- Never played a game
- Have played at least one game
- Have played more than one but less than ten times
- Have played a few games
- Play these games frequently

First Person Perspective Games (e.g. Halo, Counter Strike, Call of Duty, Etc)

- Never played a game
- Have played at least one game
- Have played more than one but less than ten times
- Have played a few games
- Play these games frequently

## SART (Situation Awareness Rating Technique)

**Situation Awareness (SA) in this study represents your knowledge of all the robots on your team (state and status).**

*Instructions: For each dimension below, please place a mark under the rating value that matches your experience with what you just completed.*

| Dimensions  | Rating |   |   |   |   |   |      |
|---|--------|---|---|---|---|---|------|
|   | Low    |   |   |   |   |   | High |
|   | 1      | 2 | 3 | 4 | 5 | 6 | 7    |
| <b><u>Demands on Attentional Resources</u></b><br><br>Demands placed on your attentional resources by completing the tasks. How much of the situational changes, number of variables, and complexity affected your SA.  |        |   |   |   |   |   |      |
| <b><u>Supply of Attentional Resources</u></b><br><br>Think of your mental state while completing the tasks. Rating should reflect your degree of arousal, your spare mental capacity, your ability to concentrate, and your ability to divide attention across multiple robots and tasks. |        |   |   |   |   |   |      |
| <b><u>Understanding of the Situation</u></b><br><br>How your understanding and knowledge of the situation affects the task performance and SA. Please rate the quantity of information available to you, the quality of that information, and your familiarity with the tasks.            |        |   |   |   |   |   |      |
| <b><u>Overall SA</u></b><br><br>You should assume a broad perspective that takes into account your entire experience while completing the tasks, and to generate a single rating that you feel best represents your SA while performing the tasks.  |        |   |   |   |   |   |      |

## **SA (Situation Awareness) Probes**

(Will be reviewed prior to user testing subject to review of the testing scenario)

### **Level 1 (Perception of information items)**

1. How many UAVs are assigned to the Victim Search task?
2. How many ambulatory victims have been identified so far?
3. How many UGVs are assigned to the Victim Assessment task?
4. How many tasks have been created by the other two operators?
5. How many UGVs are assigned to the third Victim Search task?

### **Level 2 (Comprehension of information items)**

1. Have any suspicious objects been found? (repeated three times throughout the evaluation)
2. What tasks are the EMS UAVs currently working on?
3. Have the UGVs started to triage the non-ambulatory victims?
4. What types of hazards have the hazmat UGVs detected?
5. What is the status of ambulatory victims?
6. Have the other operators' robots found any hazards or suspicious persons?
7. Have the EMS UAVs completed searching the assigned area?

### **Level 3 (Projection of future status)**

1. When will the EMS UAVs finish searching the northern part of the courtyard?
2. Where is the Guide Victim UGV moving to?
3. Why did the victim assessment task area need to be changed?
4. What is happening on 6th Street outside the courtyard?
5. Which operator, hazmat or police, do the robots in the courtyard belong to?

## **In Situ Workload Assessment**

At regular intervals (approximately every four minutes), the participants will be asked to rate their perceived workload on each of five channels: auditory, visual, cognitive, speech, and motor. The training session will include an explanation of each channel, and the Likert-type scale that will be used to rate the workload.

## **Situational Performance Metrics**

The interface will log the interaction behavior (e.g. information item hovers) of the participant during the evaluation. The administrator will record the time of non-digital evaluation events (e.g. when an SA Probe is asked). The relationships between digital and non-digital events will be analyzed for patterns that will reveal the ease of use and effectiveness of the interface in supporting the participant as he or she tries to complete the tasks given.

- How long does it take a participant to respond to the prompt?
- Is the participant's understanding of the situation correct?
- Does the participant use mouse-over or hover events to better understand the situation?



## **SUBJECTIVE COMPARISON OF DEMAND FACTORS: NASA-TLX SURVEY**

*Instructions: Indicate the demand of greater importance by circling its label on each line directly below.*

Mental Demand / Physical Demand

Mental Demand / Temporal Demand

Mental Demand / Performance

Mental Demand / Frustration

Mental Demand / Effort

Physical Demand / Temporal Demand

Physical Demand / Performance

Physical Demand / Frustration

Physical Demand / Effort

Temporal Demand / Performance

Temporal Demand / Frustration

Temporal Demand / Effort

Performance / Frustration

Performance / Effort

Frustration / Effort

## PREFERENCE QUESTIONNAIRE

Which visualization strategy did you prefer? Why?

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### 9. Schedule

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|         |   |
|---------|---|
| Sept 24 | <ul style="list-style-type: none"><li>- Due: Requirements documents</li><li>- Design RVA integration: Design how the RVA will be integrated with the existing Generalized Visualization and Abstraction (GVA) framework. Appearance (e.g. icons, etc.) and implementation (e.g. relevance rankings, simulation, etc.) will be considered for defined metrics (neglect time, cognitive workload, time to completion, etc.)</li></ul> |
| Oct 1   | <ul style="list-style-type: none"><li>- Due: Data Analysis Results; Prototyping Plan</li><li>- Prototype design will be drafted and refined. Relevant metrics will be evaluated in greater detail.</li></ul>  |
| Oct 13  | <ul style="list-style-type: none"><li>- Due: Prototype Demonstrations</li><li>- Complete RVA evaluation plan: An evaluation plan specifying simulation and testing will be drafted. Implementation will be targeted at defined metrics.</li><li>- Complete implementation of RVA: Prototype will be finished and ready to be demonstrated. Full integration with the GVA framework is expected.</li></ul>                           |
| Oct 22  | <ul style="list-style-type: none"><li>- Due: User Test plan</li></ul>   |
| Oct 27  | <ul style="list-style-type: none"><li>- User Testing begins</li></ul>   |
| Nov 17  | <ul style="list-style-type: none"><li>- User Testing Ends</li><li>- Complete user evaluation of RVA: User evaluations will be aggregated and accounted for. Changes to the RVA will be made as necessary and the existing implementation may be refined.</li></ul>  |
| Nov 30  | <ul style="list-style-type: none"><li>- Due: Project and Supporting Documentation</li></ul>   |