Royce Mou
CS 6352
Requirements Document
Robot Visualization Abstraction

1. Honor Code

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.

2. Mission Statement

The objective of this project is to develop and evaluate a Robot Visualization and Abstraction (RVA) algorithm to effectively reduce visual clutter in map-based interfaces applied to remote operation and supervision of mobile robots. This algorithm will be based on the General Visualization and Abstraction (GVA) algorithm that can ease the cognitive demands and lessen the perceived workload of a single operator tasked with supervising a team of multiple robots with high levels of autonomy (Humphrey, 2009; Humphrey & Adams, 2010). The robot visualization and abstraction algorithm will provide more comprehensive clutter reduction incorporating information specific to domain user role, the semantic content of the items displayed on the map, allowing items to be included in the system that are not displayed unless called upon, a new means to access hidden items, and applying visualization abstraction to the representations of remotely deployed robotic team members. Supporting users with more effective clutter reduction will alleviate the cognitive demands and reduce workload. User evaluations are planned to validate the new components separately and in concert.

3. User Profiles

Stakeholder 1:	First responder (operator)
User group:	Primary User
Educational Level:	Associate's Degree or higher
Computer Usage:	Minimal, but requires interaction with the provided user interface for operating a group of robots
Frequency of Use:	Frequent
Age Range:	20-50
Needs:	A clutter-free, intuitive, and responsive RVA user display to quickly summarize a given scenario and make sound, informed, and high-quality decisions in supervising a family of semi-autonomous robots
Stakeholder 2:	Incident Victims
User group:	Stakeholder
Educational Level:	Any
Computer Usage:	None

Frequency of Use:	Nonuser
Age Range:	Any
Needs:	Fast incident response and high-quality decision-making from first responders who are aided by a family semi-autonomous robots in order to minimize injury, loss of life, and loss of property

Stakeholder 3:	Robot Software and Hardware Manufacturer
User group:	Stakeholder
Educational Level:	Bachelor's Degree or higher
Computer Usage:	High
Frequency of Use:	Nonuser
Age Range:	22+
Needs:	A space and memory-efficient RVA user interface that will not leak memory or cause the system to crash. High reliability and performance is necessary to maintain the positive image and reputation of the manufacturer

Stakeholder 4:	Robot Distributer
User group:	Stakeholder
Educational Level:	Associate's Degree or higher
Computer Usage:	None
Frequency of Use:	Nonuser
Age Range:	20+
Needs:	High reliability and performance of RVA software is necessary to maintain the positive image and reputation of the distributor

Stakeholder 5:	First responder management
User group:	Stakeholder
Educational Level:	Bachelor's Degree or higher
Computer Usage:	None
Frequency of Use:	Nonuser
Age Range:	22+
Needs:	High reliability and performance of RVA software is necessary to improve the utility and effectiveness of first responders, which in turn promotes reliability and trust in the associated managing entity

Stakeholder 6:	Next responders (including second)
User group:	Stakeholder or Secondary User
Educational Level:	Associate's Degree or higher
Computer Usage:	None
Frequency of Use:	Infrequent
Age Range:	20-50
Needs:	High reliability and performance of the RVA software is necessary to improve the effectiveness of first responders, which in turn lessens the burden on the next responders

4. Inputs/Outputs

The family of semi-autonomous robots used by the first responders will be input into the system by some form of identification. The RVA software will then output a clutter-free and intuitive representation of the location, relevance, urgency, and saliency of the robots to the user display.

5. Constraints

The first responders will be under high-stress situations and so the RVA software should enable the user to make sound decisions under such conditions. The user display will be constrained by the physical size of the screen. The amount of information displayable on the screen will be constrained by the internal processing power of the robot. The amount of information displayed should also be constrained by the amount of information that is absorbable by an operator in high-stress situations. The user display is also constrained by normal incident environments; i.e. the display should be clear with a moderate amount of dust and/or with low external light levels.

6. Actual Requirements

Requirement number:	1
Requirement name:	Location and identification data
Requirement type:	Non-functional (Data)
Description:	Robot locations and data are needed as input to the RVA algorithm
Rationale:	The RVA algorithm requires robot location and identification data to work
Evaluation Criteria:	-
Requirement number:	2
Requirement name:	Reduced Visual Clutter
Requirement type:	Functional
Description:	The RVA algorithm needs to reduce visual clutter on the user display
Rationale:	The RVA algorithm is intended to reduce cognitive workload by reducing visual information processing and understanding
Evaluation Criteria:	Users can be tested on a measure of visual information retention and understanding over several user displays
Variable Range:	1-10
Requirement number:	3
Requirement name:	Reliability
Requirement type:	Functional
Description:	The RVA algorithm needs to be reliable and failsafe in incident environments
Rationale:	The RVA algorithm should not fail under moderately adverse environments as this will lead to an inability to control the family of semi-autonomous robots

Evaluation Criteria:	The RVA algorithm can be tested to operate under a number of different environments
Variable Range:	1-10
Requirement number:	4
Requirement name:	Responsiveness
Requirement type:	Functional and usability
Description:	The RVA algorithm should provide immediate feedback to the user of their actions
Rationale:	The RVA algorithm needs to be responsive in time-constrained and stressful conditions to give the operator the opportunity to correct a mistaken command
Evaluation Criteria:	Users can be tested to explain a certain sequence of actions
Variable Range:	1-10
Requirement number:	5
Requirement name:	Intuitiveness and ease of use
Requirement type:	Functional and usability
Description:	The RVA algorithm should be simple and straightforward to use
Rationale:	An operator in stressful and time-constrained situations may easily forget complex command sequences
Evaluation Criteria:	Users over the expected age range may be asked to rate ease of use on first try
Variable Range:	1-10
Requirement number:	6
Requirement name:	Use in moderately non-optimal environments
Requirement type:	Environmental
Description:	The environment in which the RVA algorithm is used should be at most moderately non-optimal (i.e. most important details can still be picked up and understood)
Rationale:	Incident and accident sites are usually moderately non-optimal, due to the nature of the job. First responders and robots will also be expected to operate in moderate conditions of wind, snow, or darkness, but cannot be expected to operate in extreme conditions of excessive heat or cold
Evaluation Criteria:	The incident site can be ranked on a scale that measures disaster intensity
Variable Range:	1-10
Requirement number:	7
Requirement name:	Adequate size of user display screen
Requirement type:	Environmental and functional
Description:	The size of the screen on which information is displayed should be relatively large

Rationale:	The size of the screen on which information is displayed should be large enough to accommodate a reasonable amount of information for the operator to handle and process. A screen that is too small where information is displayed at the same scale will not be able to provide enough information to the operator, whereas the opposite would cognitively overload the operator
Evaluation Criteria:	The screen size can be rated for comfort with use of the RVA by volunteers
Variable Range:	1-10
Requirement number:	8
Requirement name:	Adequate processing power
Requirement type:	Environmental and functional
Description:	The processor on which the software runs should be sufficiently powerful to display an adequate amount of information
Rationale:	In first responder scenarios, time is of the essence. A lag or slowdown of several seconds may make the difference between a robot arriving on time and a robot arriving several seconds late. The processor should be able to handle the processing of the amount of information that an operator can understand at a glance.
Evaluation Criteria:	The RVA algorithm can be tested at several processor speeds and can be rated for comfort by volunteers
Variable Range:	1-10
Requirement number:	9
Requirement name:	Input modality functionality
Requirement type:	User
Description:	The user should have the physical capability to interact with the user display using hands.
Rationale:	The user needs to be able to interact with and use the RVA display using a specified input modality, generally hands
Requirement number:	10
Requirement name:	Mental ability
Requirement type:	User
Description:	The user should have the mental capability to process and understand at least an average number of objects from the display
Rationale:	The user needs to be able to process and understand at least an average number of objects from the display in order to make sound decisions in supervising semi-autonomous robots.

7. Schedule

Sept 24	- Due: Requirements documents - 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.)
Oct 1	- Due: Data Analysis Results; Prototyping Plan - Prototype design will be drafted and refined. Relevant metrics will be evaluated in greater detail.
Oct 13	- Due: Prototype Demonstrations - Complete RVA evaluation plan: An evaluation plan specifying simulation and testing will be drafted. Implementation will be targeted at defined metrics. - Complete implementation of RVA: Prototype will be finished and ready to be demonstrated. Full integration with the GVA framework is expected.
Oct 22	- Due: User Test plan
Oct 27	- User Testing begins
Nov 17	- User Testing Ends - 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.
Nov 30	- Due: Project and Supporting Documentation

8. References

Humphrey, C. M., & Adams, J. A. (2009). General visualization abstraction algorithm for geographic map-based human-robot interfaces. *Human-Robot Interaction (HRI), 2009 4th ACM/IEEE International Conference on*, 289-290.