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CS 6352
Initial Project Description

Robot Visualization Abstraction Algorithm

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. Project Overview

Robotic systems are used in a broad range of domains, and vary widely in capabilities. Robotic systems can have many levels of automation, ranging from pure teleoperation through varying levels of autonomy (Sheridan & Verplank, 1978; Parasuraman, Sheridan, & Wickens, 2000). Teleoperation requires one or more human operators to specify all of the robot's actions. Mediated teleoperation allows the robot to execute predetermined sequences of events, resulting in simple automated behaviors.

In designing user interfaces for robot teleoperation, map-based visualizations are often included as they can improve situational awareness by supporting the user's understanding of the robot's location in relation to its surroundings (Johnson, Adams, & Kawamura, 2003; Nielsen & Goodrich, 2006; Trouvain, Schlick, & Mevert, 2003; Humphrey, Henk, Sewell, Williams, & Adams, 2007; Kawamura, Nilas, Muguruma, Adams, & Zhou, 2003; Fong, Cabrol, Thorpe, & Baur, 2001). If multiple teams of semiautonomous robots are to be controlled by one or more teleoperators, the number of robots displayed on the map increases proportionally. This can affect the information density, the number of information items in an area of a map relative to the screen size of that area of the map. When many robots are deployed in a single system, not all robots are equally relevant to all users at all times. A user teamed with a small subset of robots needs less information about the robots of other teams, thus making the robots of other teams less relevant. A user supervising a swarm of tens or hundreds of robots cannot directly attend to all robots at all times. Reducing the saliency of less relevant robots can reduce visual clutter.

The Robot Visualization Abstraction (RVA) algorithm will moderate the saliency of robots based on relevance, but can also incorporate neglect time to further ease the cognitive demands placed on a user. Neglect time is the amount of time a robot is predicted to operate without supervision before performance degrades below an acceptable level (Crandall & Cummings, 2007; Olsen & Goodrich, 2003). Incorporating neglect time into the RVA will ease the cognitive demands on the user by automating the task of tracking the time that elapses between user interactions with the robot. More general models have been shown to reduce cognitive workload and improve user performance, extending the convention to moderate the saliency of robots will provide the same benefits and keep the display consistent, which will promote ease of learning (Norman, 2002).

It is hypothesized that RVA enabled systems will have lower rates of robot neglect time when the user divides attention between multiple robots or multiple robot teams. Robot neglect time will be measured as the amount time that passes between the end of a robot's neglect time interval and the next user interaction with that robot.

2. Potential Users

NASA use case: Proposed NASA mission configurations include both multiple robots and varying levels of robot autonomy (Fong, et al., 2012). Incorporating automated support for these future mission configurations furthers NASA's goal of developing and common human-systems interface.

3. Related Work

The Exploration Ground Data Systems Web Tools (xGDS-WT) is an example of an interface that uses a map-based visualization to support users of a remotely deployed mobile robot. xGDS-WT is a product of the Exploration Ground Data Systems (xGDS) project, led by the Intelligent Robotics Group (IRG). xGDS-WT has been shown to provide effective support for ground-control operations of remote robotic exploration missions (Heldmann, et al., n.d.). The proposed research will further improve the map-based visualization of the xGDS-WT by integrating advanced clutter reduction and information filtering.

4. Perceived Benefit

It is expected that the Robot Visualization and Abstraction algorithm will improve user effectiveness and awareness, while decreasing cognitive workload. This hypothesis will be validated by comparing the Robot Visualization and Abstraction algorithm to other visual clutter reduction methods.

5. Preliminary Constraints

No preliminary constraints.

6. Schedule

This time line is not to simply include the project deliverables and dates, but is include detailed steps that will need to be completed to design, prototype, and evaluate the system. Please be certain you look at the course schedule to make sure you understand when particular steps are due.

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

7. References

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