User Interfaces for Multi-Robot Teams

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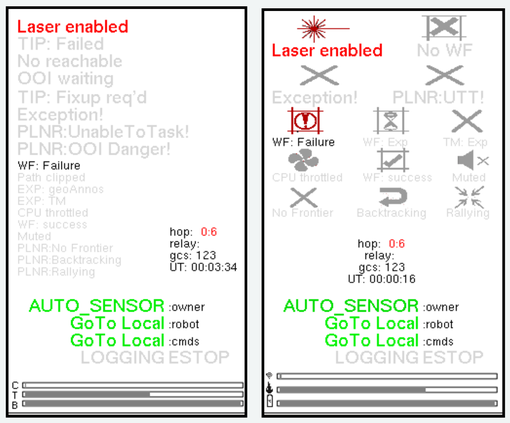
Abstract

Controlling a team of robots is a complex task, requiring human interaction via a real-time status and command interface, which often results in a complicated graphical user interface (GUI). We desire a coherent interface that provides an accurate situational awareness while minimizing the cognitive load on the human operator. We have developed and evaluated several prototype GUIs, showing that robot status is most effectively represented as a combination of text and images.

Objectives

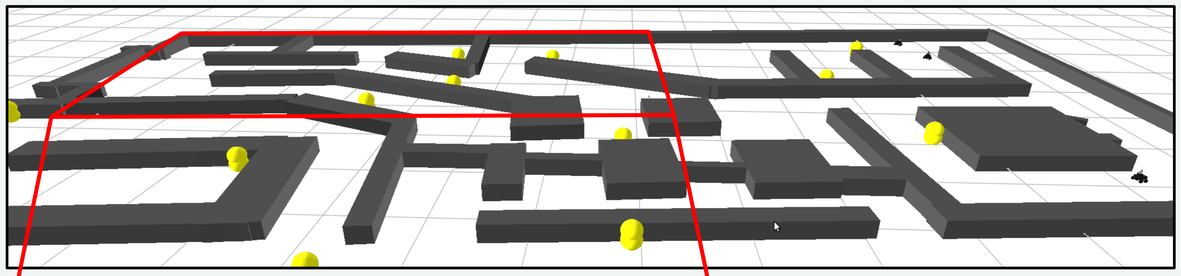
- Identify GUI characteristics relevant to intuitive robot-human interfaces
- Develop and analyze prototype interfaces based on these characteristics

Interface Design

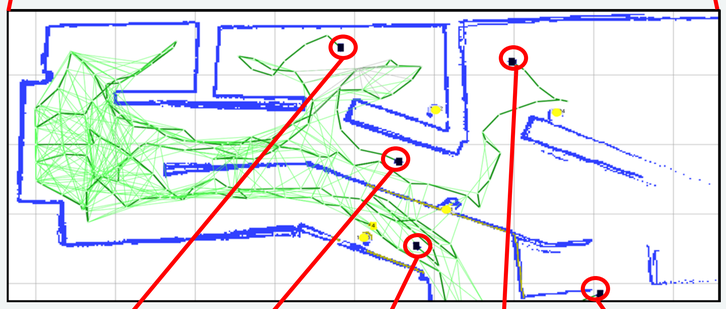


Text and icon interface provides same information as text-only with less cognitive effort

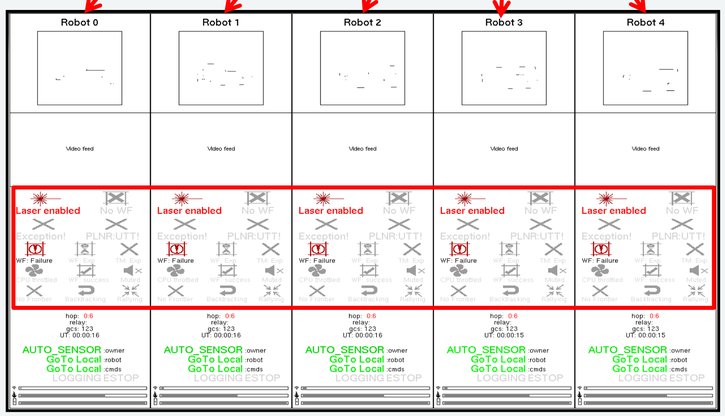
Robot Dashboard



Simulated environment with objects of interest (yellow)



Zoomed in with each robot's path (green)



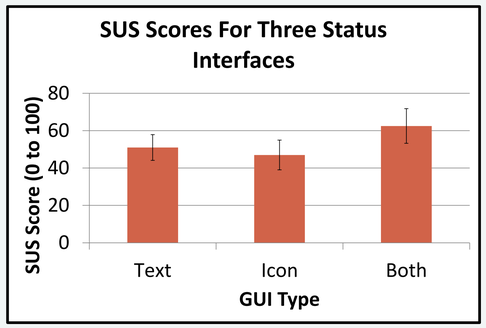
Status GUI shows real-time status of all robots

These images show a simulated environment being explored by a team of robots, a mapping of this environment, and the dashboard, in which bright colors represent important events. These interfaces provide a "real-time representation of robot state" [2].

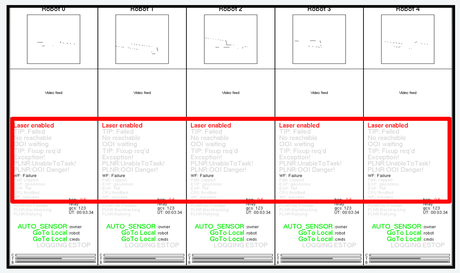
We have adapted the existing text-only dashboard to display statuses as icons and a combination of icons and text. We emphasized the "visibility of system status" and "matched the system with the real world" when designing these interfaces [1].

Results

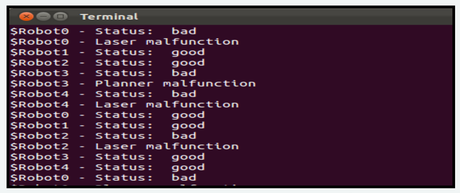
We are using the System Usability Scale (SUS) as a preliminary subjective evaluation method for our prototype GUIs [4]. The participants of this survey were students with experience with the robot system. The volunteers were given a demonstration of the system and asked to complete the SUS questionnaire. The average scores and 95% confidence intervals for each interface are shown to the right.



Cognitive Load



Robot status displayed as text



Command line robot interface

In the text-only dashboard interface, status texts flash red when the status is relevant. The images above show text-based interfaces which place a high cognitive load on the user. By improving the intuitiveness of robot GUIs, we will reduce the operator's cognitive load and improve the performance of the robot-human team.

Conclusions

- The interface comprising of text and images scored higher on average, indicating that this setup felt the most intuitive for the user.
- For future work, we plan to further improve these interfaces and perform a thorough user evaluation with quantitative metrics [3].

References

1. Keates, S. "Designing A Usable Interface for an Interactive Robot" *Proceedings of ICORR '99*. 156-160 (1999)
2. Sim, P. *et al.* "The user interface system for the Robovolc exploration robot." *Industrial Robot: An International Journal*, 31, 2, 189-200 (2004)
3. Nielsen, J. *Usability Inspection Methods*, John Wiley & Sons (1994)
4. Brooke, J. "SUS: A 'quick and dirty' usability scale", *Usability Evaluation in Industry* 189-194 (1996)