Evaluation of Tactile Feedback for Teleoperated Robots

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1 Introduction

Design guidelines and metrics proposed for robot teleoperation interfaces [Steinfeld *et al.*, 2006] tend to be difficult to apply due to high specialization of systems. Also, most guidelines only consider visual displays. Our interface uses tactile cues [Lindeman *et al.*, 2006] for feedback from robot to operator. The visual interface is based on the work of others [Johnson *et al.*, 2003; Yanco *et al.*, 2006; Nielsen *et al.*, 2007], allowing us to assess the benefits of using tactile cues.

2 System

The robot environment used in this project is completely simulated. Two virtual environments (VEs) are used. The first one represents the real world and the robot controlled by the operator. The second represents the robot control interface. The system was created on top of the C4 game engine (www.terathon.com).

The input interface consists of a Logitech Freedom 2.4GHz cordless joystick. The control simulates a robot with differentially steered wheels, such as the ATRV-JR. The system output interface consists of a 17" LCD screen and a TactaBelt with eight tactors equally spaced around the torso [Lindeman *et al.,* 2006]. The visual interface design uses as a starting point one proposed by Yanco *et al.* [2006]. It has been enhanced to contain other information on a ring displayed around the robot, similar to the Sensory EgoSphere [Johnson *et al.* 2003]. The robot is presented in third-person view as a 3D graphical model in a 3D world that also displays the robot camera's view and a 3D map with information collected by the robot, as in Nielsen *et al.* [2007].

The main distinction of our work is the addition of vibrotactile feedback to the operator control interface; the information presented on the ring is also displayed as vibratory cues through the TactaBelt. Different vibratory patterns represent different events, and vary intensity according to properties of the sensed information. Tactors closer to the direction of the sensor that captured the information are the ones triggered.

3 User Study

We are currently designing a study to evaluate the effect that using a tactile collision proximity alert interface has on operator performance. To accomplish this, operators will be asked to perform a simple search task, within a larger Urban Search and Rescue (USAR) context, with different interface settings. Subjects will use four different types of interfaces. The first interface will contain feedback using the graphical ring and the TactaBelt. The second will use only the graphical ring. The third will use only the TactaBelt. The fourth will use neither of them.

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Subjects will be asked to search as fast and thoroughly as possible for a set of six red spheres, while avoiding robot collision. The world will be represented as a closed space with debris blocking pathways. The robot cannot climb over objects. A timer will remind subjects to perform the task as quickly as they can.

Before the task, subjects will be allowed to familiarize themselves with the robot control interface in a practice VE. After the task, subjects will be asked to sketch the environment and indicate the location of the spheres. Subjects will also fill in a questionnaire capturing their impressions about the robot interfaces used.

4 Conclusions

Vibrotactile interfaces are still not used as often by the research community as they could be. We hope our results will show the benefits of such an interface for USAR-related tasks, and persuade other researchers to apply them within their own projects.

Currently, all the VEs have been implemented and tested, the input interface has been developed, and the robot is able to move in the VEs. The TactaBelt and graphical ring are currently being integrated into the system. These are the final development steps.

Once the interface is finished, a pilot study will be run to test and fine-tune the system, and to detect possible enhancements to the experimental procedure. Following this, the user study will be run to obtain the performance and preference results for validating the proposed interface.

References

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