Initial User Reactions to Robot Interfaces with Sliding Scale Autonomy and Trust Scales

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ABSTRACT

Obtaining optimal performance from an autonomous robot system requires good teamwork between the operator and the robot. Trust is an essential part of teamwork. It is also important to allow the user and the robot to fine tune the autonomy level. Existing adjustable autonomy systems do not have these features. We designed a sliding scale autonomy system that provides a range of autonomy levels. We also built a trust system on top of it that allows the user to operate the robot at the desired level of trust. First responders at the National Institute of Standards and Technology (NIST) robot test arena tested our system. This paper presents a discussion of the post-run interviews.

Keywords

Adjustable autonomy, sliding scale autonomy, robot trust.

1. INTRODUCTION AND RELATED WORK

Some robot systems have been designed with adjustable autonomy, which means that they can be operated at one of several available autonomy levels [1]. Adjustable autonomy systems have autonomy levels ranging from teleoperation (the user controls the robot's every movement) to full autonomy (the robot has full control). For example, the Idaho National Laboratory robot system has four autonomy levels: teleoperation, safe (the robot stops before colliding with obstacles), shared (the robot tries to move in the direction indicated by detouring around obstacles) and full autonomy [3]. More definitions of autonomy can be found in Huang, et al. [5].

Robots with adjustable autonomy must operate in one of their pre-defined modes; there is no notion of giving a little more control to the robot and a little less control to the user. Sliding scale autonomy provides a solution to the problem by blending human and robot inputs, thus creating autonomy levels between the few pre-programmed levels along a sliding scale. We define sliding scale autonomy as a continuum of autonomy levels.[1]

However, simply creating additional autonomy modes is not sufficient. In prior user testing, people often select an autonomy level they are comfortable with and do not change it throughout the test, even when another autonomy level would improve task performance. We are investigating approaches for making recommendations to users to change autonomy levels at appropriate points during robot usage, to allow for either more or less autonomy, with the goal of optimizing performance.

Ideally, the autonomy level should be adjusted based on both the environment and the robot state. Our recommendations for adjustment are determined based on parameters such as the environment in which the robot is currently operating, how the user handles the joystick, etc. For example, if the robot finds that the user is having a hard time controlling the robot, measured by keeping track of the joystick movements, it recommends an increase in robot autonomy. More detailed explanation can be found in [4].

Several researchers have suggested that the way robot operators select autonomy may be directly related to operators' trust in automation [8, 7]. Our interface also implements an additional set of controls to allow users to specify their trust in the robot. The purpose of these controls is to let the user interact with the robot at a level of trust he/she is comfortable with. Once the users feel confident about the system they can switch to higher levels of trust.

2. INTERFACE DESCRIPTION

We added the autonomy and trust features to an interface previously described in [6]. In Figure 1, the video display in the top center of the screen is from the front facing camera. The video display to the right is from the rear facing camera. The front and rear facing cameras can be interchanged when required by the user through the joystick. The monochromatic display below the rear camera view is from the forward looking infrared radar which is mounted in the front of the robot. Below the front video display is the distance panel. The distance panel displays the range information along with the minimum safety distance around the robot icon using a blue ellipse. The distance panel also shows three vectors: the yellow vector shows the recommended direction as calculated by the robot, the cyan vector shows the direction in which the user wants to go, and the green vector shows the direction and speed at which the robot actually

[1]Sliding scale autonomy should not be confused with sliding autonomy, a term that is sometimes used for adjustable autonomy systems [3, 2].

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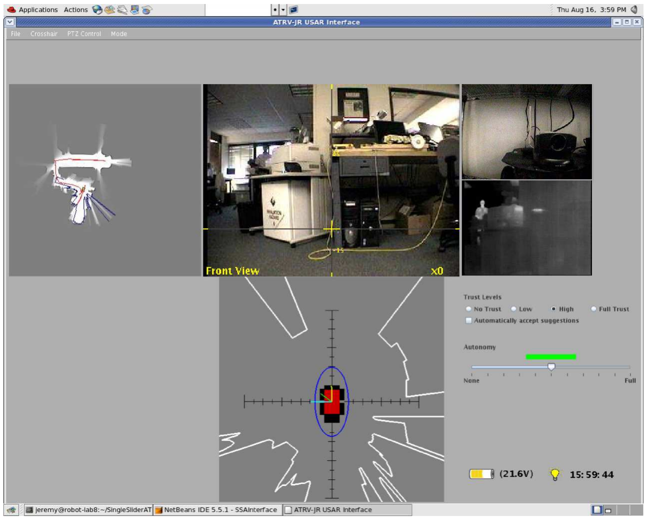

Figure 1: Screenshot of the interface.

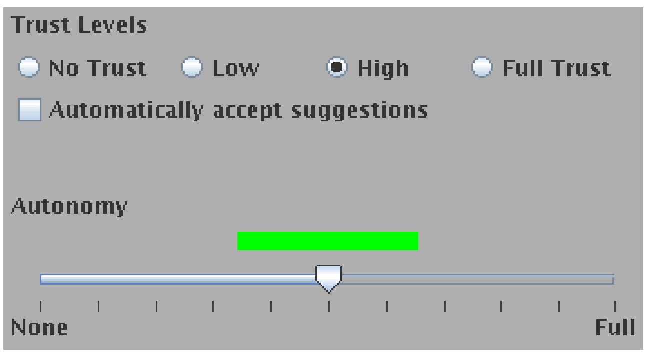

Figure 2: Zoomed in view of the autonomy slider and the trust buttons.

moves.

Figure 2 shows a close-up of the autonomy and trust panel. The user first chooses one of four levels of trust. In the no trust mode, the user sets the autonomy level using the autonomy slider and the robot makes no recommendations concerning an autonomy mode. In the low trust mode, the robot suggests a range of values as indicated by a green bar above the autonomy slider. In the high trust mode, the robot automatically implements the suggestions, and, in the full trust mode, the robot automatically sets the autonomy level.

3. INITIAL USER RESPONSE

We arranged for first responders to use the system in the National Institute of Standards and Technology (NIST) robot test arena while performing urban search and rescue tasks. Three responders searched for victims during 15-minute runs and answered post-run questions. Two responders used the system during the course of an interview that explored their reactions to the system and investigated any difficulties they were having understanding the interface.

Because the radio buttons controlling trust and the autonomy slider are presented as two separate controls, the users perceived them as being independent rather than being interrelated. Further, users often did not realize that the robot was making suggestions regarding changing the autonomy level. If they did, they did not know why the robot was making the suggestions and therefore did not accept the suggestions. One user test participant said that "if the camera vision is impaired, for example by smoke, I might accept a suggestion, otherwise I wouldn't."

These participants wanted to be able to directly tell the robot, "get me out of this tight spot and then wait for further instructions" (known on some systems as "escape" mode [3]). They were not sure whether they could do this using the sliding scale. Also, users wanted to be able to directly control the speed of the robot, which this interface didn't provide.

Several users stated that they found the blue oval around the robot icon in the distance panel helpful in determining whether the robot is getting close to obstacles. One user suggested that the vectors in the distance panel should somehow be incorporated into the video display.

4. FUTURE WORK

We have been pursuing an incremental design approach (see [6] for prior versions). For the next increment we are considering ways to show the relationship between trust and autonomy and also provide the rationale for autonomy recommendations.

5. ACKNOWLEDGMENTS

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