HUMAN-ROBOT INTERACTION

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INTRODUCTION

Human-robot interaction (HRI) is a discipline investigating the factors affecting the interactions between humans and robots. It is important to evaluate how the design of interfaces affect the human's ability to perform tasks effectively and efficiently when working with a robot. By understanding the effects of interface design on human performance, workload, and situation awareness, interfaces can be developed to appropriately support the human in performing tasks with minimal errors and with appropriate interaction time and effort. Thus, the results of research on human-robot interfaces have direct implications for the design of robotic systems.

For efficient and effective remote navigation of a rover, a human operator needs to be aware of the robot's environment [1]. However, during teleoperation, operators may get information about the environment only through a robot's front-mounted camera causing a keyhole effect [2]. The keyhole effect reduces situation awareness which may manifest in navigation issues such as higher number of collisions, missing critical aspects of the environment, or reduced speed [3, 4]. One way to compensate for the keyhole effect and the ambiguities operators experience when they teleoperate a robot is adding multiple cameras and including the robot chassis in the camera view [5]. Augmented reality, such as overlays, can also enhance the way a person sees objects in the environment or in camera views by making them more visible. Scenes can be augmented with integrated telemetry, procedures, or map information. Furthermore, the addition of an exocentric (i.e., third-person) field of view from a camera placed in the robot's environment may provide operators with the additional information needed to gain spatial awareness of the robot.

Two research studies investigated possible mitigation approaches to address the keyhole effect: 1) combining the inclusion of the robot chassis in the camera view with augmented reality overlays, and 2) modifying the camera frame of reference. The first study investigated the effects of inclusion and exclusion of the robot chassis along with superimposing a simple arrow overlay onto the video feed of operator task performance during teleoperation of a mobile robot in a driving task. In this study, the front half of the robot chassis was made visible through the use of three cameras, two side-facing and one forward-facing. The purpose of the second study was to compare operator performance when teleoperating a robot from an egocentric-only and combined (egocentric plus exocentric camera) view. Camera view parameters that are found to be beneficial in these laboratory experiments can be implemented on NASA rovers and tested in a real-world driving and navigation scenario on-site at the Johnson Space Center.

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