USING A TACTILE GLOVE FOR MAINTENANCE TASKS IN HAZARDOUS OR REMOTE SITUATIONS

1. INTRODUCTION

As our dependence on automated systems has increased, demand for maintenance of these systems has increased, regardless of the environmental conditions of the systems. Therefore, mechanical tasks, such as replacing a screw, needs to be performed in situations dangerous for a humans, such as a nuclear reactor. In addition, mechanical tasks need to be performed in remote environments that may not be directly accessible by a technician, such as repairing sensors deep in the Antarctic ice shelf. These individuals require the use of a robotic interface to carry out mechanical tasks for maintenance in these environments.

Most mechanical tasks in these situations are performed by robots with end effectors that are controlled by a human (Jenkins, 1986). However, technicians may find it more useful to perform a task manually than with a standard robot due to the tactile feedback based on the grip and pressure that they are applying. Because hazardous situations prohibit a human from physically performing the task without the aid of a robotic interface, tactile gloves, which are gloves that can provide input/output to a computerized system, have the potential to provide feedback from the operational environment in a safe way to the operator while enabling the operator to perform the task manually (Caldwell and Gosney, 1993).
Despite the work done with tactile gloves and standard robotic interfaces, researchers have not conclusively presented which option yields a higher task accuracy. The results of such a study can optimize both task performance and operator satisfaction in stressful situation in hazardous and remote environments. This paper proposes that using a tactile glove will yield greater task accuracy and operator satisfaction than using a standard robotic interface in hazardous or remote situations that involve precise actions.

In the remainder of the paper, I review the work done with tactile gloves in terms of expanding its range of potential uses, specifically in providing input/output to an individual as well as in some hazardous and remote environments. I then discuss the limitations of previous studies in terms of assessing task accuracy of using a tactile glove. Finally, I discuss an outline of an experiment to assess the task accuracies and operator satisfactions of using a tactile glove and a joystick/mouse in hazardous and remote environments.

2. REVIEW OF THE LITERATURE

Over the past three decades, work on tactile gloves have expanded its range of potential uses and enabled individuals to interact with other individuals and objects in different environments. This section reviews work on using tactile gloves to transmit/receive information from different types of computerized systems. In addition, this section reviews work that demonstrates the potential of tactile gloves to improve task accuracy in hazardous and remote environments.

2.1. TACTILE GLOVES USED FOR TRANSMISSION OF INFORMATION

Tactile gloves are predominantly used in the computing and systems industry to provide communication of tactile and haptic information to virtual objects on some computer system. In
addition to transmitting information to a computer, computer systems used tactile gloves to relay information from the computerized system to the user. Without the ability of using a tactile glove to provide input/output communication between an individual and a computerized system, operators would not be able to use a tactile glove to complete mechanical tasks.

Tactile glove interfaces have enabled input and output communication between an individual and a computerized system for engineering applications. Combined with multi-modal input, tactile gloves were used to enable a user to control a robotic arm based on the shape of the user's arms, hands, and fingers, through the use of flex-sensors (Fischer et al. 1987). An individual can use a device that senses movement from his or her limbs and appendages to control a robotic device to perform some engineering task, which provides a basis for work involving performing a mechanical task with a tactile glove. In addition, tactile interfaces were used as feedback for haptic input interfaces, such as force feedback in CAD/CAM applications (Burdea, 1999). While the flex-sensor apparatus for controlling a robotic arm provided input communication to a computerized system, the force feedback in the CAD/CAM applications provided output communication to the individual controlling the computerized system.

Tactile interfaces have also enabled individuals with disabilities to control a computerized system. A tactile interface for a haptic application has enabled visually-impaired individuals to gain more information about files stores on a computer or application through only touching keys (Wall and Brewster, 2006). This interface demonstrates how the tactile functionality provide more-precise user control over tasks on the computer, which can also be observed in the use of a graphics tablet to draw on a computer. Because visually-impaired individuals may not find standard haptic interfaces useful (such as a mouse or joystick), tactile interfaces afford more individuals, particularly individuals with disabilities, the ability to interact with computerized systems to accomplish a task.
2.2. Tactile Gloves Used in Information Transmission in Hazardous and Remote Environments

Researchers have shown tactile gloves to be useful in transmitting information in hazardous and remote environments. In these situations, information must either be readily available and distinguishable or must be detailed enough to gain a sound understanding of another environment. Both conditions must be satisfied in the context of using a tactile glove to perform a mechanical task in a hazardous or remote environment.

Soldiers have demonstrated a noticeable benefit from having simple tactile communication between members of a unit in a battlefield. In this scenario, soldiers used a tactile system to issue simple commands or messages to one another by touching a button on a display, and the recipients would feel the message on different parts of their body, depending on the message sent (Gilson et al., 2007). The tactile system reduced the load on auditory and visual channels and diversified the communication load, thus allowing more information to be transmitted in a hazardous battle.

Tactile interfaces enable communication of real-world object information from one remote environment to another through the use of sensor systems. Tactile interfaces have enabled the communication of friction, roughness, and softness of a real-world object to an individual that is controlling the robot that is “feeling” the object (Yamauchi et al., 2010). This system enables the transmission of tactile qualities of an object to an individual, which will prove useful toward performing a precise mechanical action, such as inserting a screw into a nuclear reactor.

2.3. Task Accuracy Comparison Between Standard Robotic Interface and a Tactile Glove

Information regarding tactile sensations, such as heat and pressure, can prove useful for
conducting an experiment assessing the task accuracy of a tactile glove system. A remote instrument finger, which is a form of a tactile system, successfully transmitted heat and pressure information to an individual without harming the person (Caldwell and Gosney, 1993). However, this system did not assess any information regarding task accuracy or operator satisfaction of the feedback given from the instrumented finger.

Standard robotic interfaces (with the use of a mouse or a joystick) are the standard in practice for completing tasks in hazardous or remote environments. However, tactile glove interfaces appear to be better suited for completing these tasks in many situations. Because researchers have not executed a thorough study comparing the task accuracy or operator satisfaction between a standard robotic interface and a tactile glove, this raises the question: will using a tactile glove yield greater task accuracy and operator satisfaction than using a standard robotic interface in hazardous or remote situations that involve precise actions?

2.4. SUMMARY OF THE LITERATURE REVIEW

Through research on tactile gloves over the past three decades, tactile gloves have expanded in use to different applications, from providing user input/output on computerized systems, to facilitating communication between individuals and real-world objects. While tactile gloves have proven applicable to providing communication in hazardous and remote environments, researchers have not compared the performance of a standard robotic interface and a tactile glove interface in terms of task accuracy and operator satisfaction. Knowing the result of such an experiment can enable operators in these situations perform their jobs with both a greater degree of accuracy and a higher satisfaction in their work.
3. **Conclusion**

In this paper, I reviewed the need for having a robotic system to complete tasks that humans cannot readily execute due to location or severe environmental condition. I then reviewed how tactile gloves can provide new ways to provide input and receive output from computerized systems and their potential to providing adequate communication in hazardous and remote environments. Finally, I described the lack of a thorough study that assessed task accuracy and operator satisfaction between a standard robotic interface (joystick/mouse) and a tactile glove system.

From the question proposed by this paper, I would devise an experiment that would test the task accuracy of using a tactile glove against the task accuracy of using a standard robotic interface (with a joystick) in a hazardous situation. For example, I would devise a scenario involving replacing a screw inside a nuclear reactor, which would involve unscrewing the old screw, taking out the old screw, placing the new screw into position, and screwing the new screw into position. Other scenarios can be devised for operators to test each apparatus on, so long as each scenario involves a precise action where the individual cannot easily complete the task by entering the environment where the task is to be completed. At the end of each scenario, a questionnaire is given to the operator to assess operator preference and the scenario designer will assess the result of the action according to a pre-defined rubric that permits level assessments (such as having a task 75% completed). I expect the results of this study to demonstrate that operators strongly prefer the tactile glove to the standard joystick interface and this preference will cause the task accuracy with the tactile glove to be higher, likely because operators will be more confident with using the tactile glove.
REFERENCES


