Haptic Teleoperation of a Robotic Arm

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The Robot

The robots used for these experiments are Barrett Whole Arm Manipulators (WAMs), each equipped with a three fingered Barrett Hand. The WAM is controlled by cable transmissions, giving it both a high degree of accuracy and a low susceptibility to friction. A key feature of the WAM is its open-loop backdrivability. This means that a force applied to any point of the robot will affect the entire arm.

What is Teleoperation?

Teleoperation is the remote control of a machine from an outside location. The outside location could be as close as the same room or as far as the other side of the country. The concept of teleoperation has been around for several decades and the term is often used in academic and research environments instead of the more colloquial term "remote control."

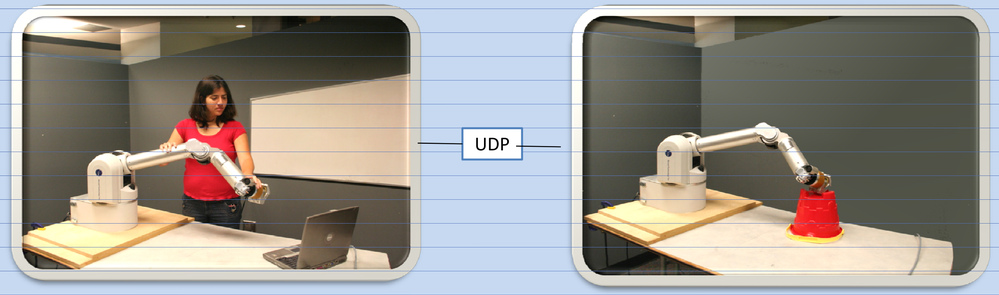
Because of the separation of the operator and the equipment, teleoperation is used when the work environment is too hazardous for humans (ex. radiated areas). Other implementations of teleoperation can be seen in surgical operations, space exploration, and emergency rescue situations.

Related Work

Teleoperation in robotics is often setup as a Master/Slave relationship as shown by Zhou et al. In this experiment they used a 7 DOF WAM to control a 6 DOF Titan II 6-D Manipulator. In their study they had to account for several factors found in teleoperation: differences in the Master/Slave equipment and the corresponding control systems. In this study the robots were operated using Cartesian space.

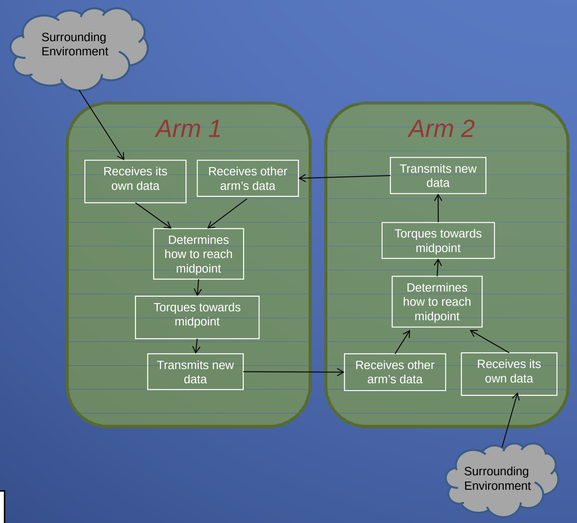
Telepresence (similar to teleoperation but featuring a more abstract view of location), was the focus of the study by Anser et al, which dealt with the use of robotics and pre-modeled haptics (physical feedback) to create simulated training environments. These environments allowed surgeons to practice without actual patients. In this study a WAM was utilized to control the surgeon's tools and deliver the haptic feed back.

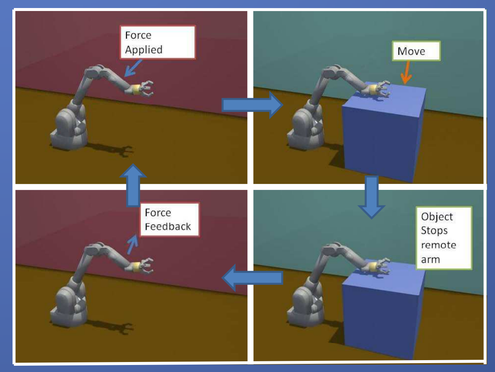
Haptic Teleoperation



Abstract

We aim to create a system in which two Barrett WAMs will control each other for the purpose of enabling real-time haptic teleoperation. If one WAM is moved then the other will move with it. In this way the operator will be able to feel any resistance encountered with the remote robot. To evaluate our method of haptic teleoperation, we will examine how it can improve upon, or even replace, teleoperation based solely on visual information. We will compare performance with combined visual and haptic information to performance with each one individually.





Experiments

Weight Perception- We investigated how accurately a user can judge the weight lifted by a teleoperated arm.
Maze Navigation- We tested a user's ability to guide the arm through a maze.
Ring Stacking- We evaluated how well a user can use the remote arm to place rings on a peg.

Uses of Haptic Teleoperation

Our research explores many of the usability challenges arising in robotic applications such as:

Surgery – The Barrett WAM has already been approved by the FDA for use with knee surgery. Remote teleoperation could allow a surgeon to operate on a patient from a remote location. In this way, the best surgeons in the world could be available at many different satellite locations, saving travel time and expenses.

Manufacturing - The capabilities of the Barrett WAM make it extremely versatile in the context of manufacturing. Currently there are a variety of jobs in manufacturing that require a human operator expose himself or herself to the dangers of a hazardous working environment to do a specific task. If remote teleoperation is used, all the benefits of having a human in control can be achieved without the hazardous working environment

Search and Rescue- An Urban Search and Rescue robot equipped with a similar arm would be able to act on its environment. A human operator could take control of the robot to help clear debris from its path, or reach into small places.

References

Anser, Adnan, et al. "Visual and Haptic Collaborative Tele-presence." 7 Sept. 2001. Computers & Graphics, Vol. 25.

Zhou, Renbin, et al. "Using the WAM as a Master Controller." 2001. Oak Ridge National Laboratory.

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