A SIMULATED ENVIRONMENT OF A MULTIMODAL USER INTERFACE FOR A ROBOT

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Abstract

The Multimodal User Control project at the Applied Science and Engineering Laboratories (ASEL) is developing a strategy that allows for user control of a rehabilitation robot through the use of multiple modes of interface. The strategy combines pointing to indicate locations and verbal commands to identify objects and actions. The intent of the multimodal control system is to meet the needs of individuals with motor disabilities by allowing them considerable freedom and flexibility to operate a robot in an unstructured environment [1].

To study the intricacies of the interactions between the user and the envisioned multimodal control system a simulated environment is being developed. The simulated environment will be used by consumer researchers to help determine the best way to enable a user to direct commands, control execution of tasks, and communicate environmental parameters which the robotic system is unable to ascertain.

Background

To date, interface strategies for rehabilitation robotics have not met the desires of the disabled community [2]. Command-based interfaces, in which the robot is programmed with predefined movements, expect the items that the robot is manipulating to be in predetermined locations [3][4]. This limits the system to a set workstation type environment. While control-based methods allow the user control of all movements and offer more flexibility than command-based system, they are often slow and very demanding of the user [5][6]. Alone neither of these interface strategies allow the user to effectively operate a robot in an unstructured environment.

The multimodal interface strategy focuses on the integration of command-based and control-based methods in combination with voice recognition of commands and gestures to indicated locations of objects and the desired trajectories that the user wants them moved along. This strategy involves a number of technical developments in order to maintain the simplicity of the user interaction. To accomplish this the multimodal control system will include a Zebra-Zero robot, sensing devices, a three-dimensional machine vision system, and a computer [1].

The multimodal user control interface strategy also makes the user an integral part of the robotic system. The multimodal control system uses the user's intelligence and senses to significantly augment its knowledge base, reactive planning and artificial sensing devices. This scheme allows the user to define the size, shape, color, location, name, etc. of an object, thus relaxing the object recognition requirements of the system.

Statement of the Problem

The development of the multimodal user control strategy depends heavily on the user's spatial perception and interactions. The user's perception of the depth, distance, orientation, and configuration of objects are particularly essential to how the multimodal control system will respond to directives from the user. Although the system does not require the user to provide information about the depth, distance, orientation and configuration of objects, understanding the user's perception of these features is important to insure that commands are executed as the user intended. To design a robust multimodal control system we must first take into consideration:

- How the user perceives the location and orientation of objects
- How the user interacts with objects
- The interplay between the user and the simulated multimodal control system
- How to gather an accurate interpretation of the speech and gestural intimations the user makes
- What level of automation allows the user the best control and flexibility
- How to provide effective feedback to the user as to the multimodal control system's interpretation of their intentions

By studying these issues we will be able to more effectively explain and predict the interactions between the user and the multimodal control system.

An additional challenge which needs to be addressed is the issue of user safety. When the user gives the multimodal control system a command they are expecting the system to carry out that task without injuring them and without damaging the objects it is manipulating. Besides conventional safety rules and intelligent safety devices, an additional method of providing feedback to the user about the plans of the system needs to be developed.

Approach

To prototype and evaluate the multimodal interface strategy, a simulated multimodal user control environment is being created using JACK™, an application developed by the Center for Human Modeling and Simulation at the University of Pennsylvania [7]. JACK™, which runs on a Silicon Graphics IRIS Elan computer, graphically displays articulated geometric figures and allows them to be placed and manipulated in a virtual environment. This virtual world (as shown in Figure 1) contains a fully functional model of the Zebra-Zero robot, models of general objects such as books, cubes, pencils, cups, etc., a 3-D tracking device and other inputs sensors, and a kinematic manipulatable human figure. The simulated environment will also have the advantage of a knowledge based reactive planner. The knowledge based planner allows for flexible and reactive planning in an unstructured real-world domain. The planning mechanism allows for both autonomous planning as well as planning through human-machine interaction [8].

Consumer Participation in Research

The simulated environment's combination of the virtual multimodal user control world and the knowledge based reactive planner will allow it to efficiently evaluate the user's perception and interpretations of a multimodal user control interface strategy. To gather this information and to refine the human factors considerations, extensive consumer research with the simulated multimodal control environment will be conducted. Consumer researchers will be asked to work with the simulated multimodal control environment and will be involved in suggesting changes to the simulation system, which can then be easily implemented for reevaluation. The prototyping steps which will be used in the development of the simulated multimodal control system are:

1) Develop a virtual representation of all the components which exist in and affect the actual multimodal control environment
2) Expand the user command and control features of the simulated environment
3) Conduct consumer evaluations of the performance of the simulated multimodal control system.
4) Implement the consumer suggestions and repeat step 3.
5) Define the strategies for multimodal user control of a rehabilitation robot which will be implemented in the actual multimodal control system

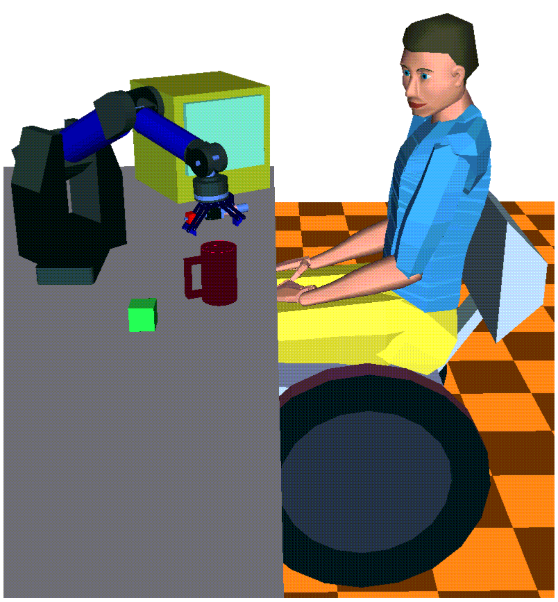

Figure 1: The Simulated Multimodal User Control Environment

The Simulator as a Plan Previewer

To address issues of plan correctness and user safety, the simulated environment will also be incorporated into the multimodal control system during its actual operation as a feedback mechanism. The simulated environment will inform the user of the system's plans and interpretations of the world and can be thought of as a "plan previewer". After the user gives the system an instruction, they will first be able to preview what the system intends to do, via the simulated environment. This is very important because when the user entrusts the multimodal control system with a task, they are "trusting" the system to perform that task correctly. In doing this the user is also taking a "risk" that the system can do the job correctly [9]. The simulation environment is apropos to the trust/risk issue. If the user is going to command the system to perform a task, they need to be confident that the system is going to perform the task adequately. By allowing the user to visually preview of the intention of the multimodal control system, the simulation interface will effectively strengthen the "trust" between the user and the multimodal control system.

The functionality of the simulated environment will gain additional strength as a previewer by taking advantage of the three-dimensional machine vision system. The simulated environment can graphically render parametric object shape models that are extracted by the vision system. This feature allows more of the nuances of the user's real environment to be incorporated into the virtual representation, which allows for more realistic simulations of the multimodal control system's intentions.

Implications

The overall objective of the simulated environment is to improve the design of the interaction strategy for the multimodal control system by rapidly incorporating the consumers' suggestions into the system. The aforementioned method of integrating the creative talents of consumer researchers with the engineering knowledge of the project team will hopefully produce innovative solutions to the problems found when multimodally controlling a rehabilitation robot. An additional goal of the simulated environment is to address the issues of user safety and plan correctness in the multimodal control system by giving the user the option of viewing the actions before the actual multimodal control system performs the actions. This previewing technique should help to reinforce the user's confidence in the system, consequently increasing its effectiveness and usability.

Summary

This research is attempting to set forth a new technique for controlling a rehabilitation robot and to influence the design of robotics technology. Present techniques of controlling a rehabilitation robot have not been adequate, because they failed to consider the needs of the disabled community. The extensive use of consumer researchers gives this project access to knowledge and experiences that cannot be provided by traditional research techniques. It is believed that this consumer insight will help to produce a human-robot interaction strategy which is flexible, efficient and intuitive.

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