Human-in-the-Loop Control of an Assistive Robot Arm

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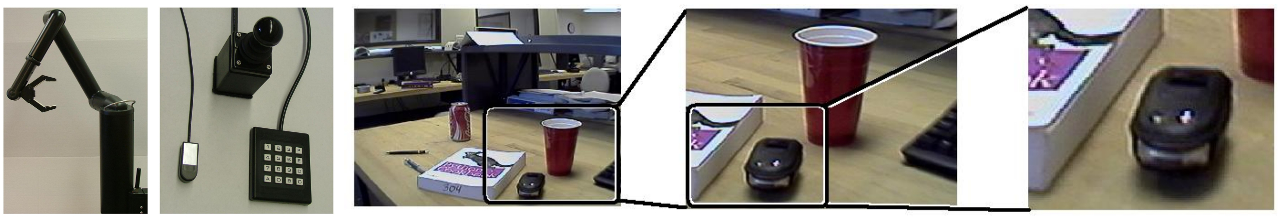

Fig. 1. Manus ARM (left); Standard Controllers (second from left); Selection Process for Gross Motion

I. Introduction

Severely disabled people rely on help from their loved ones or a hired caretaker to assist their daily lives. Mechanical devices allow limited independence to users, thus improving their quality of life. One such device is the Manus Assistive Robotic Manipulator (ARM), manufactured by Exact Dynamics [1].

Accomplishing an activity of daily life (ADL) with the ARM, such as retrieving an object, requires skillful manipulation and takes on the order of magnitude of minutes to execute. For a user who has very limited manipulation, this is already an improvement. However, direct control is imperceptive, tedious, and frustrating.

Our goal is to provide better methods for independent manipulation of an unstructured environment. We take advantage of the human in the loop and combine input from the computer vision processing to provide the user with an intuitive controller.

II. Hardware

The ARM has a two-fingered gripper end-effector and is a 6+2 degree of freedom (DoF) unit with encoders on its joints. A user may directly control the ARM by accessing menus via standard controllers: keypad, joystick, or single switch. The Joint menu allows the user to manipulate the ARM by moving joints singularly. The Cartesian menu allows the user to move the gripper of the ARM in a line through the xyz plane (3D); multiple joints may be moving simultaneously in preplanned trajectories. Alternatively, the ARM can be transparently controlled by CAN-bus communication from a PC. In transparent mode, joints may also move collaterally.

Some enhancements have been made to the ARM. Two cameras have been added: one to the “shoulder” and another to the gripper. A touch screen display supplies visual feedback to the user and can also be used as an input device.

III. Human-Robot Interaction for Gross Motion

The gross motion human-robot interface makes use of the human in the loop via explicit input selection, and computer vision techniques implicitly using Phission [2], our multi-threaded vision system.

One possible interaction method is to directly select an object from an image on the touch screen. However, a large part of the target population will not have the fine motor skills necessary for direct selection. Therefore, we have designed a method for selection compatible with single switch scanning.

Initially, the user is presented with an interactive image of what the ARM can “see.” The image shown is quartered, and the user selects, by touch or single switch, the quadrant in which the majority of the object that they desire to manipulate is located. Instead of joint-by-joint reconfiguration, the whole ARM moves in the xy plane, emulating human motion control, towards the center of the selected quadrant.

The quartering and moving procedures are repeated a second time; the view is 1/16 of the original image, and the gripper of the ARM physically centered on the object’s xy position. Then depth z is computed using optical flow, and the gripper moves close to the desired object. To grasp it, control then cedes to fine motion, which is currently under development.

Acknowledgment

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References

[1] Exact Dynamics 2006, http://www.exactdynamics.nl, accessed on June 29, 2006.
[2] P. Thoren, “Real-Time Vision Procession System”, http://www.phission.org, April 2004.