Design and Evaluation of a Laser Joystick in a Fixed Turret Assembly

Erin Rapacki, Katherine Tsui, and Holly Yanco
University of Massachusetts Lowell

David Kontak
Crotched Mountain Rehabilitation Center

Supported in part by the National Science Foundation (IIS-0534364 and IIS-0546309)

Abstract

People naturally look at and point to objects. A laser dot can provide the same cue in the world. We have integrated a Class II eye-safe laser pointer into a turret assembly for people who need assistance selecting and handling objects outside their physical range of motion. We evaluated our laser joystick by conducting a within subjects experiment (laser joystick versus a standard presentation pointer) with six participants from Crotched Mountain Rehabilitation Center (CMRC). The results and comments from the experiment have provided guidance for modifications in the next iteration of the laser joystick.

Problem Statement

Our goal is to design a device to allow people with limited upper limb mobility to control a laser pointer to make object selections in their environment. Abstraction can be a limiting factor for people with cognitive impairments. For example, someone who understands a physical instance of an object, such as an apple, may not understand that a picture of the apple represents the same object. Yet people must use abstractions to make selections to control robot arms and other computer devices. Laser pointers have been investigated by the field of human-computer interaction as an input device for object selection. Our laser pointer will be integrated with a wheelchair mounted robotic arm to indicate an object for a "pick-and-place" task.

Background

The naturalness of using laser pointers to point to objects has been explored in assistive technology by research institutions such as Kanagawa Institute of Technology and Georgia Tech. At the Kanagawa Institute of Technology, a joystick was used to control a servo driven laser pointer mounted to the wall to control a ceiling mounted robot arm [1]. Georgia Tech created the "clickable world" concept [2]; a laser pointer was used to direct a mobile manipulator to move objects.

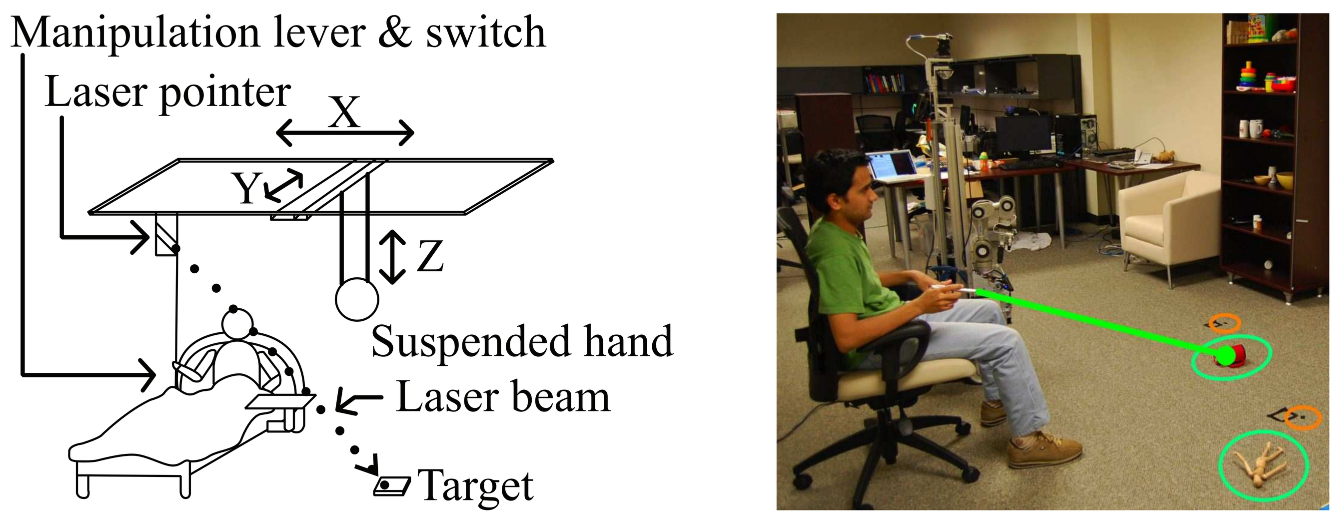

Figure 1. (Left) Knagawa Institute of Technology [1]. (Right) Georgia Tech [2]

There are assumptions about using laser pointers in assistive technology that must be addressed, such as the dexterity and range of motion needed to manipulate a device. Kanagawa Institute of Technology used a joystick, which is a well-established access device in assistive technology. However, McLaurin noted that a joystick is "far from ideal for many users" [3]. Also, the dexterity and range of motion needed to hold a laser pointer pen for Georgia Tech's "clickable world" interface is quite high. Thus, we have embodied the laser into a joystick-like assembly.

Design

We have embodied the laser into a joystick-like assembly to minimize assumptions relating to dexterity and range of motion for manipulation of the device. Our laser pointer will be integrated with a wheelchair mounted robotic arm to indicate an object for a "pick-and-place" task. The sensor suite on the prototype laser joystick included:

- two potentiometers to measure vertical and horizontal rotation (similar to [1]),
- an infrared distance sensor,
- and a laser diode for visual feedback to the user.

The size of the joystick started with the width of the distance sensor, which constrained the targeting end of the joystick handle to two inches. The shape of the handle is an eight inch long cone for three reasons: 1.) to provide ease for gripping, 2.) make it look like a wand (affordance of pointing), and 3.) offer more surface area for a person to tap or nudge it from the side (ADA closed fist test).

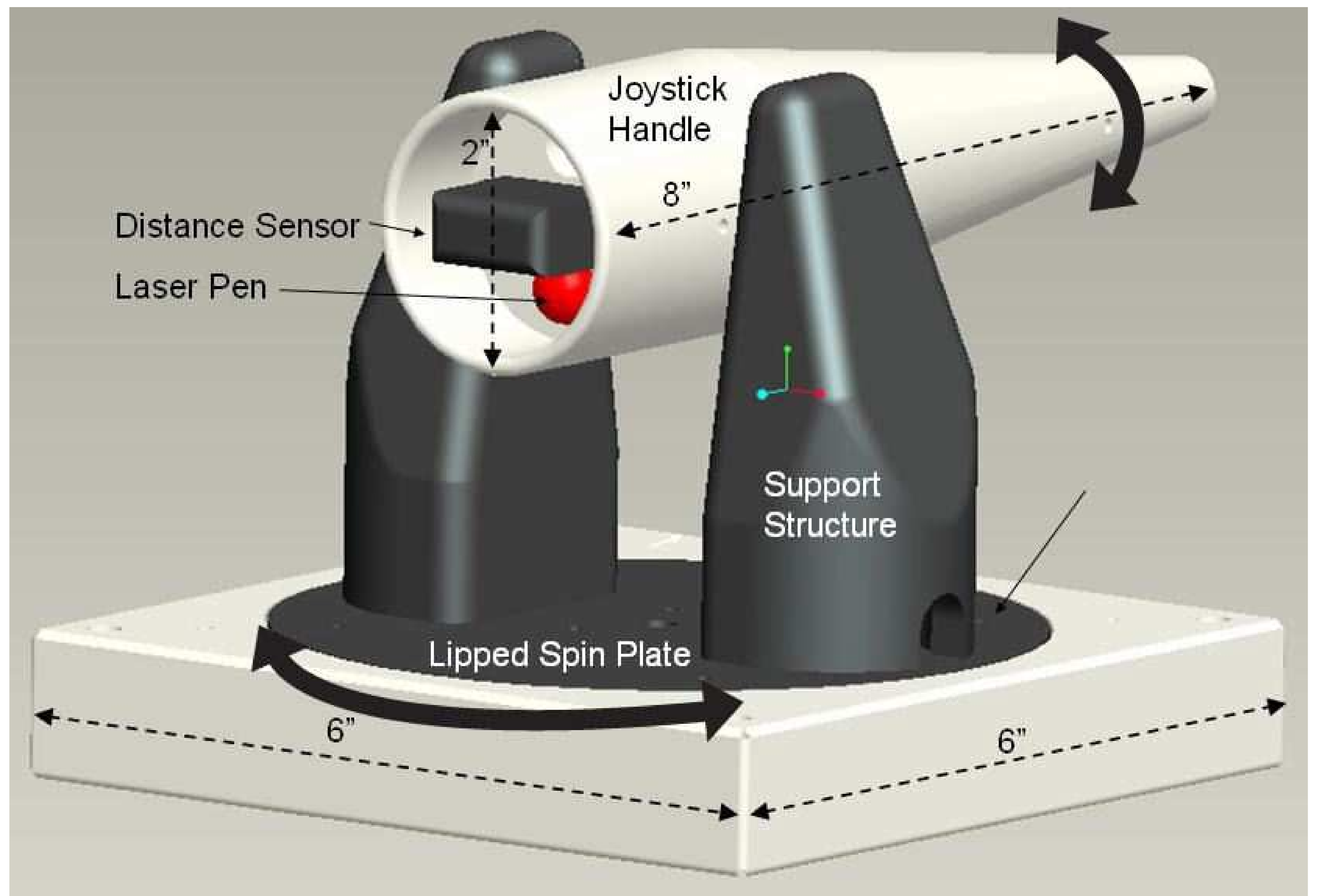

Figure 2. Diagram of laser joystick

The dimensions for the other parts in the joystick stemmed from the size of the conical handle. There were no bearings integrated into the assembly. Friction between tightly fitting rotational surfaces allowed the joystick to hold its position when all forces and loads from a user were removed. A first prototype was grown in a Dimension 3D printer using models drawn in ProEngineer (see Figure 2). A Class II eye-safe laser pen, represented by the red dot, was used in this prototype as visual feedback. The curved black arrows indicate the two rotational joints for left and right (horizontal), and up and down (vertical).

[1] Takahashi, Y., M. Yashige, M. Nakamura, and E. Hirata. Human Interface and Vibration Control of Robotic Manipulator Suspended from Ceiling. In *Transactions of the Institute of Measurement & Control*, 24 (5), 387401, 2002.

[2] Nguyen, H., C. Anderson, A. Trevor, A. Jain, Z.Xu, and C.C. Kemp. El-E: An Assistive Robot that Fetches Objects from Flat Surfaces. In *Proceedings of the HRI-08 Workshop on "Robotic Helpers: User Interaction, Interfaces and Companions in Assistive and Therapy Robotics"* March 2008.

[3] McLaurin, C. A. Current directions in wheelchair research. *Journal of Rehabilitation Research and Development* 2, 8890, 1990.

Evaluation

We evaluated the laser joystick with six end-users from Crotched Mountain Rehabilitation Center. Each participant used both laser devices to point at a total of six objects. Afterwards, the participant was asked about his/her experience and solicited for improvements to make the laser joystick easier to use.

Table 1. Participant profiles

	Age	Diagnosis	Physical Ability	Cognitive Ability	Behavior	Vision	Wheelchair	Computer Access
P1	35	Cerebral palsy	Significantly challenged, but moderately functional	No significant impairments	No significant impairments	Corrected with glasses	Power	Standard with left hand only; slow buy functional
P2	18	Cerebral palsy	Significantly challenged, but moderately functional	No significant impairments	No significant impairments	No significant impairments	Power	Standard (limited dexterity)
P3	21	Cerebral palsy	Significantly challenges, but moderately functional	Mild deficits	No significant impairments	Mild deficits	Power	Standard with left hand only; slow but functional
P4	18	Muscular dystrophy	Limited strength, dexterity, and range of motion	No significant impairments	No significant impairments	No significant impairments	Power	Standard
P5	17	Cerebral palsy	Mildly impaired, but functional in most situations	Some mild involvement	No significant impairment	Corrected with glasses	Power	Standard
P6	17	Spinal Bifida	Good manual dexterity	Mild deficits	Mild deficits	Mild deficits	Manual	Standard (limited dexterity)

Results and Discussion

Ability to use the laser joystick. Five of the six participants were able to use the laser devices to point at objects. All six participants stated that they liked using the laser dot to point at objects in the environment. Four of the five participants said that they were able to see the red laser dot on the red trash bin. Four of the five stated that the water bottle was harder to see.

Preference between laser joystick and presentation pointer. Two participants (P1 and P2) indicated that the laser joystick was easier to use, and three participants (P4, P5, and P6) indicated that the presentation pointer was easier to use. P1 and P2 both have spasticity in their hands. P2 has flexion in her wrist.

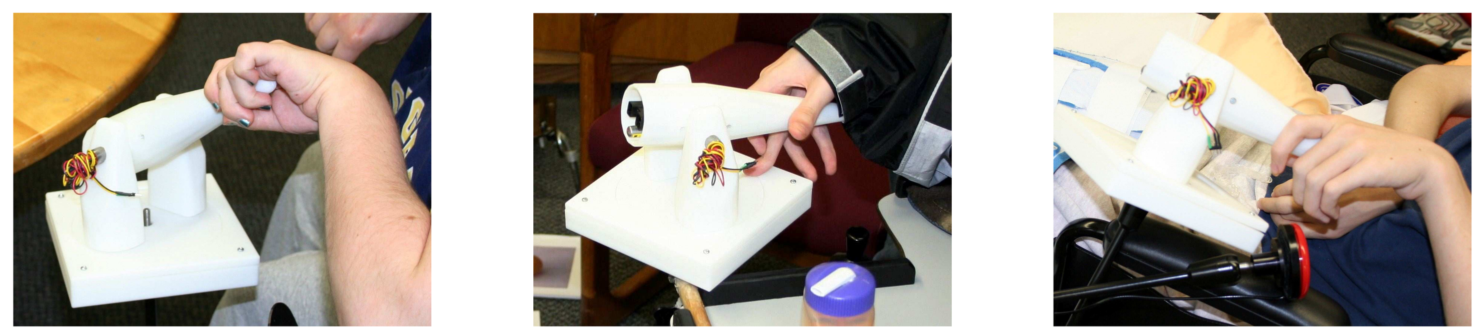

Figure 3. Hand position of P3, P4, and P5 respectively gripping the laser joystick

Of the three participants who preferred the presentation pointer, all had good dexterity in their hands. Our occupational therapist noted that P4 (see Figure 3) was interesting to observe because, in general, he has less range of motion than P3 (see Figure 3). P3 was unable to operate either laser device due to accessibility issues. She has internal rotation of her shoulder and also flexion in her wrist. While P3 was able to grasp the laser joystick, she was not able to move it well horizontally, which was likely caused by a combination of the spasticity in P3's hand and mount location of the laser joystick.