

# TASK: PM-3 INPUT DEVICES AND CONTROL CONCEPTS

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## Rationale

The interface between the wheelchair user and the wheelchair itself is often the most critical component of the powered wheelchair. Hand operated joysticks with proportional control are now the traditional method of interface for most wheelchair users. Sip and puff control, head control, chin control, single switch are further options for those that are unable to access the joystick.

## Goals

The objective of this task was to review existing input and controller technology and explore technical options for enhanced performance, reliability and safety given current market needs and the evolving national standards for microprocessor-based wheelchair controllers.

## Methods and Outcomes Summary

The results of a focus group meeting to identify the most significant issues impacting input devices and control concepts for powered mobility devices held during the first funding period has been reported (Brienza, et al, 1995).

A research and development plan consistent with the needs identified by the focus group and compatible with the goals and objectives of the RERC was conducted. The long-term goal of this research is to develop a control system that integrates navigational and obstacle detection sensors into a control system that assists the driver of a wheelchair in both known, i.e., mapped, and unknown environments. Potential applications of the system include obstacle avoidance in known and unknown environments, execution of predefined maneuvers such as traversing through a doorway or following along a wall, assisted navigation along predefined paths through a known environment and as a driving skills training device for powered wheelchair users. Developments during the first project period

concentrated on the application of assisted obstacle avoidance using a force feedback joystick. During the second period the two control algorithms were further developed.

Two philosophies have guided the design process: 1) ultimate control of the wheelchair must remain with the driver and not with the control algorithm; and, 2) mobility efficiency must be maximized. Providing the user with the ability to apply the decisive control input signals distinguishes this wheelchair control system from that of an autonomously guided vehicle. The driver remains in control of the decision making element of the system and at no time is an action initiated without allowing the user to override the suggested action. Also, any input action should result in a predictable response from the system so that the user is not required to decipher the control algorithm in order to accomplish a desired task.

The object of the control system is to assist the driver in negotiating obstacles as fast as possible and with as little cognitive and physical effort as possible. It is undesirable to slow down the wheelchair. This would decrease efficiency or burden the driver with excessive monitoring tasks, making the wheelchair more difficult to drive. Instead our objective is to influence the steering of the wheelchair using force feedback from the active joystick. Note, however, that the user may choose to counter the suggestions of the control system by overcoming the joystick's force resistance.

Since the conceptual development of these control modalities, this task concentrated on implementation of a system for the evaluation of the concept.

An evaluation of a force feedback joystick for a powered wheelchair was performed. The study aim was to determine if the device enhanced the driving performance of experienced wheelchair users. A prototype device was constructed and used with a virtual reality system for the evaluation phase of the



study. The force feedback joystick is shown in Figure 8. Test subjects used the force feedback joystick as a prototype to navigate a wheelchair through a virtual environment with and without the force feedback algorithm activated (Figure 9). According to the position of the wheelchair in the virtual environment, the force feedback algorithm changed the compliance of the joystick making it more difficult to move the joystick in the direction of an obstacle. The factors that were used to determine the compliance of the joystick were 1) the angle between the wheelchair velocity vector and the displacement vector of the closest obstacle, and 2) the speed of the wheelchair. The subjects were experienced power wheelchair users with marginal ability to control a wheelchair using a conventional proportional joystick. Their performance using the force feedback joystick was measured using the time needed to complete a run through the course and the number of collisions with the obstacles. The test course is shown in Figure 10. The results showed that one out of the five subjects who participated in the study had fewer collisions when the force feedback algorithm was activated compared to their performance when the algorithm was not activated.

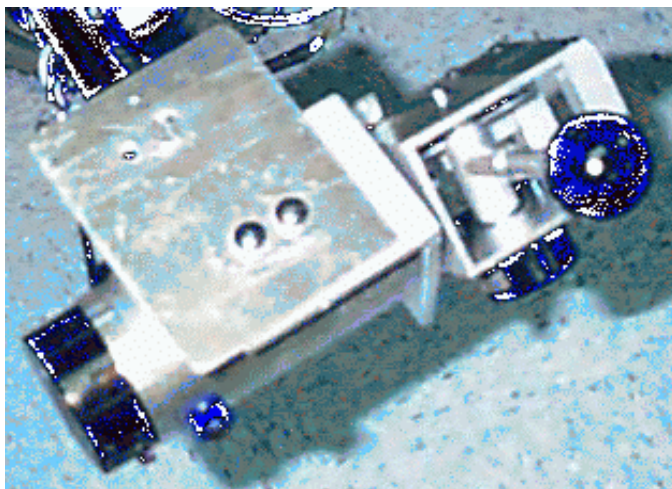


Figure 8 - Picture of force feedback joystick



Figure 9 - Picture of a subject using the system

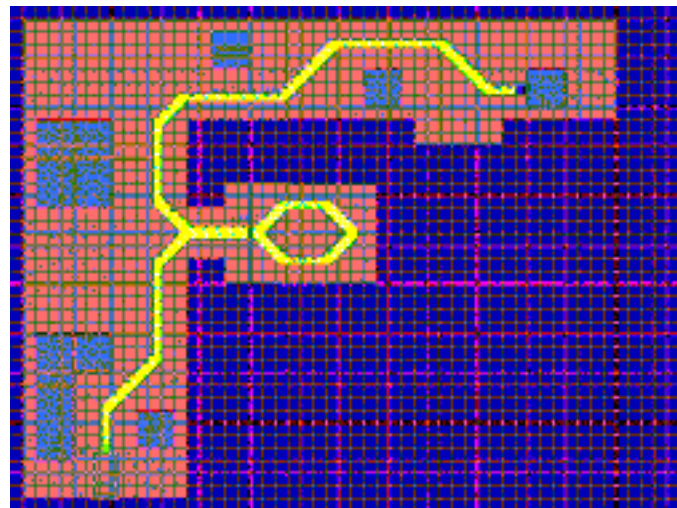


Figure 10 - Diagram of test course.

## Publications

Brienza, D.M., Angelo, J.A., Henry, K. Consumer participation in identifying research and development priorities for power wheelchair input devices and controllers. *Assistive Technology*, July 1995.