Integration of Electronic External Devices for Powered Mobility Systems

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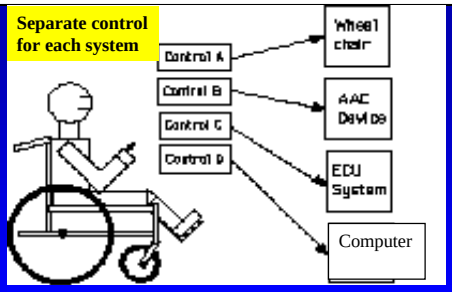
Scope of the Project

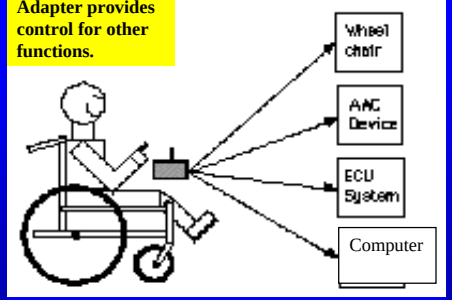
Many people who use powered wheelchairs can benefit from using the wheelchair controller to operate other functions. This project is exploring new options for implementing this function with improved performance over traditional approaches

Separate control for each system



Distributed Controls

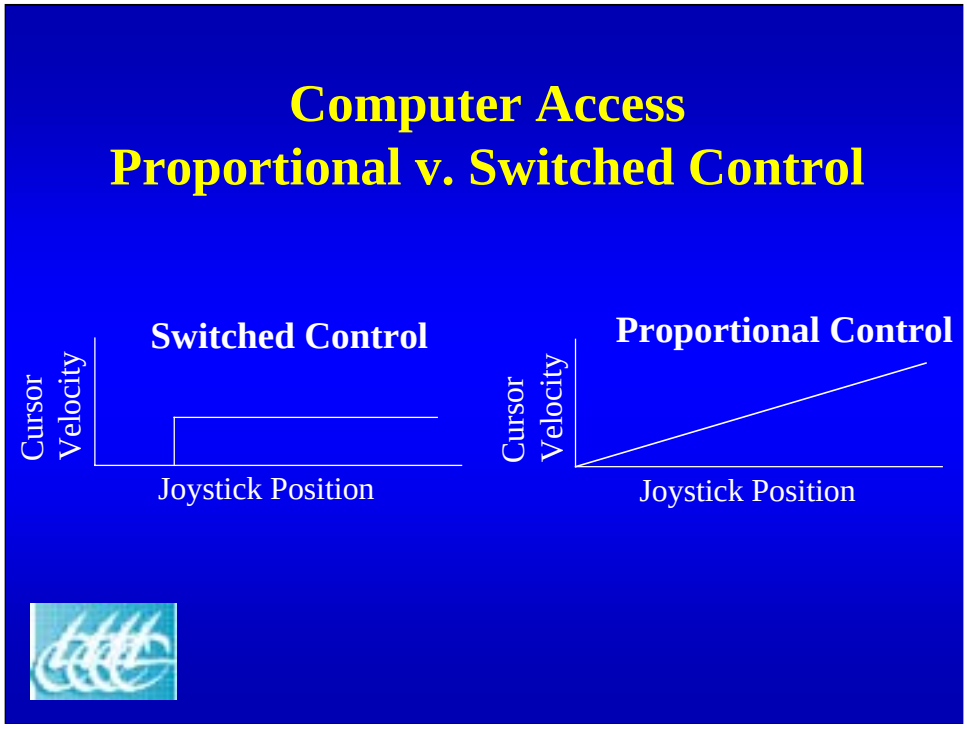
Joystick to Mouse Adapter provides control for other functions.



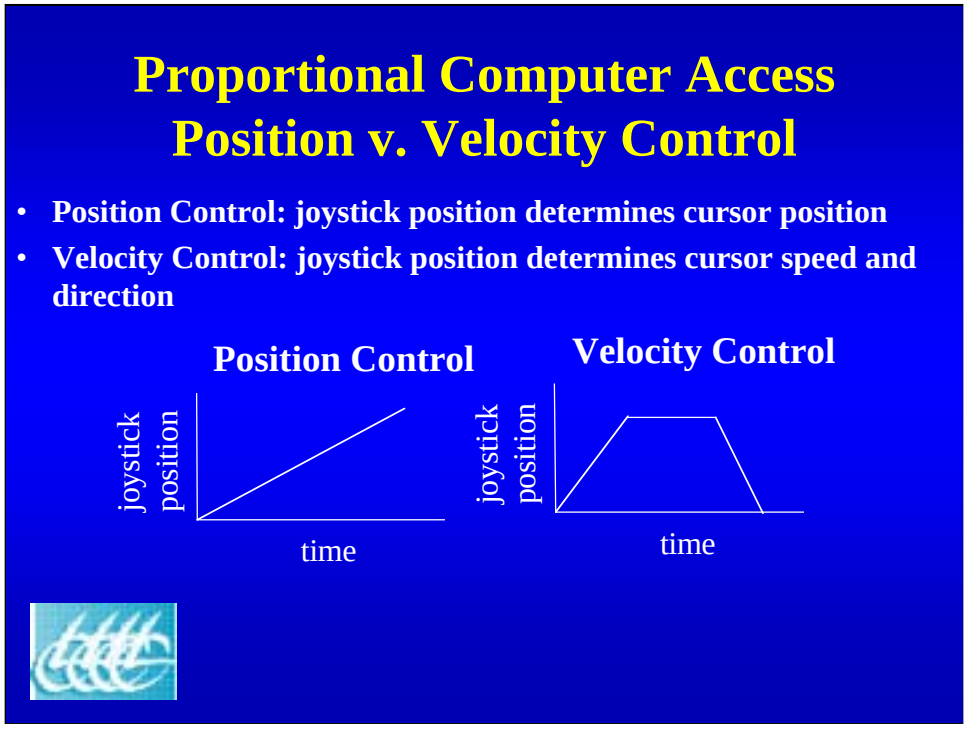
Integrated Control

Elements of the Project

- Definition
  - Survey
  - Literature review
- Development
- Evaluation
- Technology transfer



One particular application of an integrated control system is to provide computer access through a person's wheelchair controller. Some existing devices already allow a person to operate a computer using a wheelchair joystick. However, these devices translate information about joystick position into four switch inputs. This allows a person to control the direction of cursor movement, but not the cursor's speed of movement; rather the cursor will move at a constant speed. It would be desirable if a proportional wheelchair joystick (one which allows the driver to control both wheelchair direction and wheelchair speed) could also control both cursor direction and speed on the computer.



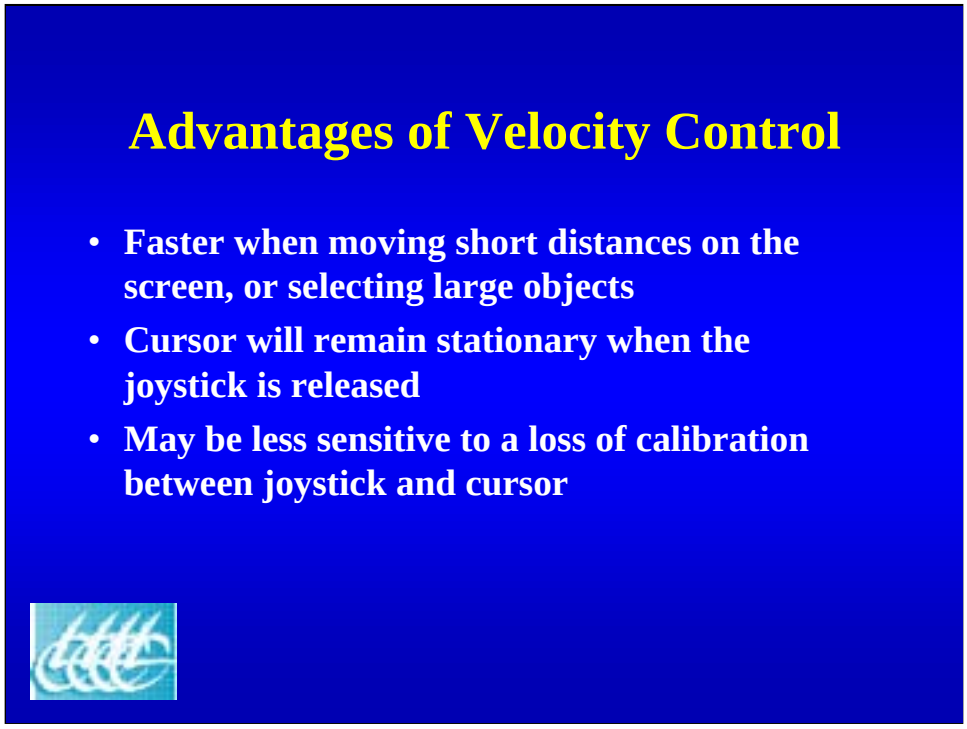
There are at least two ways in which such proportional control could be provided: position control or velocity control. With position control, the joystick position determines cursor position. With velocity control, joystick position determines the cursor's speed. In order to select an on-screen icon, the user of a position-control system will move the joystick to a position associated with the position of the icon on the screen. The user of a velocity-control system will move the joystick once to select a direction and speed for the cursor. The user will hold the joystick steady until the cursor is close to the target, then move the joystick back to the center in order to stop the cursor on the icon.

Advantages of Position Control

- **Position control is faster at higher indices of difficulty**
- **Jagacinski et al. 1978**
  - **Position control is faster for an index of difficulty greater than 4.7 bits**
  - **4.7 bits →**

    distance to target > 13 x width of target

Researchers comparing these two methods have found that position control is faster at higher indices of difficulty. In one study, Jagacinski and colleagues found that position control is faster for an index of difficulty greater than 4.7 bits. This index of difficulty corresponds to a situation in which the distance to a target is 13 times the width of the target. These studies indicate that selection of a computer icon with a position-control system is generally superior to selection with a velocity-control system.



However, velocity control also has advantages. Based on these same studies, velocity control is superior for targets with a low index of difficulty. Therefore, velocity control is expected to be faster when moving short distances on the screen, or selecting large objects.

Also, with velocity control a person can release the joystick and the cursor will not move, since the center joystick position corresponds to zero velocity. The person can then concentrate on performing a button click. In a position-control system, it is necessary to hold the joystick at a desired position while also performing a mouse button click.

Finally, a velocity control mode may be less sensitive to a loss of calibration between joystick and cursor, because a particular joystick position does not have to remain mapped to a specific screen location.

Therefore, while research indicates that selection of a stationary icon with a position-control system is generally superior to selection with a velocity-control system, this superiority could be mitigated by factors affecting real-world computer control. In order to design an interface between wheelchair controllers and computers, it is desirable to determine whether position control or velocity control is most useful in a real-world setting. Therefore, both methods are being implemented and evaluated in a prototype integrated control system.

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Mouse Emulation

Brief Definition:

In an integrated controls environment, providing the option of using the wheelchair joystick as a computer mouse.

Possible Approaches

RERC D-2 task considered two methods of providing computer mouse access:

- 1. Directly translating wheelchair analog signals into mouse format.

2. Working with a wheelchair joystick which contains a data port provided by the manufacturer.

Some Existing Options

- Gus software
- Penny and Giles mouse joystick
- Permobile infrared system

Direct Analog Translation Goals

- Ability to process two channels of analog signals; from wheelchair joystick and possibly other force transducers
- Output should be in a standard mouse format, Serial, PS/2 or USB and work with standard mouse drivers.

Constraints

Avoid reinventing mouse controller chip that interacts with the computer's mouse port.

Rationale for this decision:

- Public would expect support of multiple formats, PS/2, Serial, USB, Older Mac ADB.
- Hardware that can perform this task is readily available at low cost.

Investigation

- Searched for a commercial mouse controller chip that would accept analog input and translate it into mouse format.
- Only prospect located to date is the HulaPoint™ by USAR systems. Used with Hall effects transducer on handheld systems.

Investigation Results

Except for the HulaPoint ™, all other mouse controller chips reviewed required quadrature data at the input pins.

Quadrature is the digital data format generated by a mouse's rolling ball driving two optical shutter wheels.

Analog to Quadrature Translation

- Time does not permit a formal discussion of the electronic circuitry used to convert analog signals into quadrature format.
- Consult RESNA proceedings or consult with the authors.

Summary of Solution

- Devised a low cost circuit (Radio Shack parts) that translates analog signals into the digital quadrature.
- Purchased a mass market mouse and “hotwired” the controller chip pins.
- Plug the commercial mouse into a standard computer mouse port.
- Commercial mouse “thinks” the digital signals are coming from its own roller ball.

Advantages

- Circuit built from inexpensive generic technology.
- Prototype has been tested with standard serial and Logitech wireless mouse boards. Should work with any rolling ball mouse or trackball: Serial, PS/2, USB, Wired, and Wireless versions.
- Target computer runs standard mouse driver.
- Possibility of connecting other analog signals in addition to joysticks; i.e., Hall effects transducer, photo sensor, strain gage, piezoelectric.

Disadvantages

- Currently a build-it-yourself, experimental solution, requires electronic construction skills, no commercial tech support.
- Expect the usual problems motivating tech transfer – costs of tooling a PC board for small volume production.
- “hot wiring” commercial products voids warrantees. Mice are cheap, wheelchair joysticks are not. Better if the manufacturer provides access to signals.

Joystick to Mouse Adapter

- Input: Invacare Mk IV controller plus two switches (left and right mouse buttons)
  - Serial joystick position (1 byte per axis)
- Output: IR wireless to mouse emulator
- Modes
  - Position control
  - Velocity control
  - Hybrid
- Adjustable gain


POWER
SWITCH
POSITION CONTROL
VELOCITY CONTROL
HYBRID CONTROL
POSITION GAIN
VELOCITY GAIN
JOYSTICK
TO MOUSE
ADAPTER
ACTIVE
LEFT
(-)
SELECT
RIGHT
(+)

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Testing

- Subjects
  - People who use powered wheelchairs and have good joystick control
- Modes
  - Position, velocity, and hybrid control
  - Traditional switch system
- Tasks and Units of Measure
  - Target acquisition (Ed LoPresti, Pitt)
    - bits per second
  - Typing Instructor driven by WiViK
    - words per minute