

An Evaluation of an Obstacle Avoidance Force Feedback Joystick

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Abstract

- An evaluation of a variable compliance force feedback joystick for a power 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 evaluation. The factors that were used to adjust the compliance of the joystick were 1) the angle between the wheelchair velocity vector and the edge of the closest obstacles, and 2) the speed of the wheelchair. The results showed that four 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.

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Full Citation

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Study aim:

- Determine if a force feedback joystick enhances the performance of power wheelchair users

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Background

- Many varieties of input devices and control interfaces have been developed for power wheelchairs to satisfy the diverse needs for people with disabilities.
- However, there are still some people with physical impairments for whom there are no input devices.

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Background

- Previous studies investigated obstacle avoidance of power wheelchairs.
- These systems temporary limit the driver's ability to control the wheelchair.

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Our system

- Provides driver with constant control
- Wheelchair senses obstacles, warns user, and prompts user with a course of action
- The driver can override the wheelchair's path.

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Two philosophies

- Passive assist - joystick resists movement toward obstacle
- Active assist - joystick actively pushes away from obstacle

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Efficient algorithm

- Pilot work indicated active assist gave users maximum efficiency

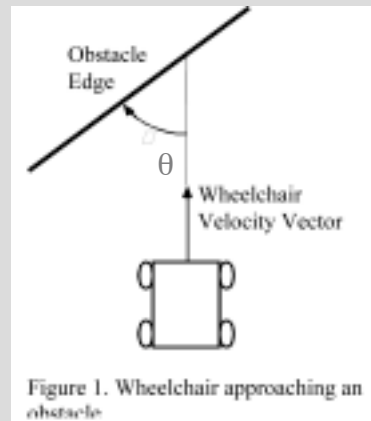
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Magnitude of force

Depended on:

- time-to-hit (speed)
- angle between velocity of wheelchair and edge of closest obstacle
- position of joystick



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Two axes of rotation

- One for speed
- One for steering



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Joystick Encoders

- Encoders in the joystick provided information about desired speed and direction.
- Based on this information, joystick changed compliance.

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Joystick Motor Controller - TE5650 interface board

- Located in PC
- Used for communication between software and hardware.
- Provided force feedback by controlling a motor coupled to the joystick steering axis.
- Simulated original joystick for the wheelchair's controller

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Virtual Reality System

- Used because wheelchair did not have obstacle detection features.
- Developed virtual test courses.
- Position of wheelchair was determined by movement of wheels.
- Position of virtual obstacles were known by computer.
- Virtual reality glasses provided visual feedback to subject.

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Subjects

- 5 subjects (3 female and 2 male)
- Aged 33 to 56
- Averaging 47.6 years
- 4 with Cerebral Palsy; 1 with Post Polio

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Subjects

- Experience varied from 1 to 20 years All experienced in using hand-operated proportional joystick.
- Average experience was 8.4 years with median of 5 years.
- Daily use varied from 2 to 16 hours.

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Procedure

- Explained procedures and obtained informed consent.
- Joystick was adjusted.
- Subjects became accustomed to system by navigating practice course with and without force feedback.
- Demonstration of test course.

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Procedure (cont'd)

- Subjects navigated through test course 8 times - 4 with the feedback and 4 without the feedback.
- Post-interview was administered.

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Data Recorded

- Completion time
- Number of collisions
- Distance traveled
- Average speed
- Successful completion of turn around?
- Time spent completing turn around

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Results

	w/o Force Feedback	w/ Force Feedback
Completion Time (secs)	298.04 ± 137.13	304.84 ± 154.79
Number of Collisions	9.78 ± 8.20	8.56 ± 7.92
Distance Traveled (ins)	1094.18 ± 158.45	1074.63 ± 86.59
Average Speed (ins/sec)	3.67	3.53

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Discussion

- 4/5 subjects had fewer collisions with the feedback activated.
- Fifth subject used his powered wheelchair the least.

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