VARIOUS TYPES OF WHEEL CHAIR CONTROL METHODS: A REVIEW

Deepthi J\textsuperscript{1}, Col Dr T S Surendra\textsuperscript{2}
\textsuperscript{1}(EEE, Padmasri Dr B V Raju Institute of Technology, Narsapur, India,}\textsuperscript{2}(EEE, Padmasri Dr B V Raju Institute of Technology, Narsapur, India,)

ABSTRACT

The purpose of this review is to highlight the wide array of interfaces developed so far to control wheel chairs. A preliminary study on wheel chair interfaces is presented. This is followed by various types of powered wheel chair control methods such as hand, voice, communication methods and hybrid. Wheel chair control methods for persons with reduced strength are also explained. Apart from all these topics various stair case climbing mechanisms developed are also studied. Some of the tests employed are also discussed in short.

KEYWORDS: Assistive Technology, Control, Mobility, Quadriplegic, Wheel Chair

1 INTRODUCTION

Spinal chord injuries lead to Quadriplegia in human beings. Quadriplegic persons are in dire need of wheel chairs. Quadriplegia has several levels from C1 to C8 depending on location of injury. The degree of paralysis increases with level of quadriplegia. According to a recent survey, 82\% of men and 18\% female are prone to spinal chord injuries. 47\% of spinal cord injured individuals are considered quadriplegic. Approximately 11,000 new injuries occur each year. 56\% of injuries occur between the ages of 16 and 30. The average age of spinal cord injured person is 31. The causes of spinal chord injuries are given in Fig. 1.
2 REVIEW OF VARIOUS TYPES OF WHEEL CHAIRS

2.1 Preliminary study
The requirement of appropriate seating for elderly staying at nursing homes was studied in [1]. In this paper, problems related to discomfort, mobility and posture were explored. Some of the concerns expressed by wheelchair users were addressed in [2] by giving slight negative camber. Cambering is the method of angling the wheels such that bottoms of wheels are farther apart than tops. Angle is varied from $+15^\circ$ to $-15^\circ$ and effects on nine selected variables were studied.

2.2 Hand control
Maneuvering of wheelchairs was made easy by bending the fingers using gloves with flex or bend sensors as explained by Akmeleawati, R et al. in [3]. Sports hand rim controlled wheelchair dynamics and musculoskeletal mechanisms were studied in [4] to prevent injuries and optimizing performance. Functional effectiveness of different types of gloves was studied by Mason BS et al in [5] specific for wheelchair rugby. A semi-autonomous robotic system, robotic arm with persons with upper limb impairments and disability of legs was designed by Martens [6]. The user interface of this model consists of speech and flat screen interfaces. In order to control multi sensor intelligent wheelchairs, a force reflective feedback system was developed by Luo [7]. A Microsoft Force Feedback Pro joystick which can give input and also simulate certain conditions such as effects of wall, shake, force etc., was used.

2.3 For patients with reduced strength
Among several models proposed for driving powered wheelchairs for quadriplegic persons, legacy adapted mode was explained in [8] by Urbano. A part of formal operation model along with STAGE simulator evaluation where in parameters have to be tuned to each patient is also incorporated. He also explained a bionic approach of Artificial Intelligence to Assisted Powered Wheelchair for people with severe impairments in [9]. Electrocardiogram and skin conductance sensors were used to detect stress. Control unit has to take environmental and stress data into consideration in order to trigger actuating commands. Intelligent control and navigation systems were included in robotic wheelchair named as MAid (Mobility Aid for Elderly and Disabled People) [10].
2.4 Using communication methods

Telerehabilitation consultation model for evaluation of remote wheelchair prescriptions was used to explain the methodology, development and implementation of assistive technology service delivery protocol by teleconferencing in [11]. Live interaction of occupational therapist with expert therapists will enable the access of this service to remote and rural locations.

A wireless intra-oral module using zigbee protocol is explained in [12] to control not only wheel chairs but also cursor of computer and other home appliances. This is found to be a reliable, low power and cost effective way to improve quality of spinal chord injured persons.

2.5 Powered Wheel Chairs

User friendliness study of wheelchair control interfaces for persons with severe disabilities was presented in [13]. A Microsoft® Sidewinder™ force feedback joystick 2 for a powered wheelchair was evaluated in [14] to determine displacement vectors of sixteen sensors to nearest obstacles. It has been further inferred that all subjects reported fewer collisions and passage of corridor, crossing of door became much easier with feedback.

In order to improve the functional mobility of people using electric powered wheel chairs a review of work done in the areas of velocity control, traction control, suspension control, stability control, stair-climbing wheelchairs, and wheelchair navigation was presented in [15]. On similar lines, a review of assistive devices for powered wheelchair navigation was presented by Arhsak in [16]. A new joystick interface technology was proposed in [17] to aid persons with special needs and disabilities. A smart wheelchair design was explained in [18]. This employs several components such as Infrared Sensor, SONAR sensor, drop off detectors etc., to make a normal powered wheelchair as a smart wheelchair.

2.6 Voice control

Voice controlled powered wheelchair was proposed in [19]. Comparison of performance of able bodied subjects using voice to control the wheelchair with and without navigation assistance was demonstrated. Another voice based wheelchair based on speech recognition and microcontroller was explained in [20]. This was found to be simple, portable application with low power requirement.

2.7 Hybrid control

A low cost hybrid wheelchair was investigated [21] in which the electric assist portion of the design would act similarly to a wireless self-powered torque sensor, allowing for an array of applications besides the electric assist portion of this project. Features of voice, eye tracking, motorized and environmentally controlled wheelchair was developed by Roberts [22]. A hybrid wheelchair for real world environment was proposed in [23]. In this paper four robotic legs with three degree of freedom and independent steering and driving motors interface wheels. Wheel chair based on hybrid powering (combination of arm and electric power) was simulated in [24]. This will result in a reduction of arm force required to drive wheelchair. The operation of push rim activated power assisted wheelchair was studied in [25]. In this wheelchair, human power is delivered by the arms through the push rims while the electric power is delivered by a battery through two electric motors.
2.8 Stair climbing wheel chair

Stair climbing and descent is facilitated by making front and rear wheel clusters connected to base via powered linkages in [26]. Kinematic model of stair climbing wheel chair during ascent and descent is presented in [27]. Two decoupled mechanisms were used in each axle. One mechanism takes care of climbing the steps and other takes care of the slope.

2.9 Tests

A “bedside” test of rear wheel chair stability using goniometer and plumb line was conducted in [28] to assess static stability. In this paper the inter and intra observer reliability and validity in comparison with platform testing were assessed. It has been observed that “bedside” test is reliable, valid, simple and more suitable screening test to assess rear stability. Functional performance of consumers using wheel chairs as primary mobility device was studied in three phases [29]. Test-retest reliability and content validation of outcomes tool designed to measure effective intervention on functional performance of wheel chair users was studied in [30].

A customized mechanical and electronic braking system to eliminate safety hazards due to user’s limited hand functionality is studied in [31]. The system was also evaluated by minimum force test to ensure effective braking for quadriplegic users.

3. CONCLUSION

Inspite of the development of innumerous ways to control wheelchairs still several novel methods are being experimented. Some of the interfaces to control wheel chairs have been discussed in this paper. The information gathered in this study is meant to promote awareness of status of existing types of powered wheel chair control technology and improve the mobility of wheel chair users.

4. ACKNOWLEDGEMENTS

I express my profound sense of gratitude for Department of Science and Technology for funding this project. I would also wish to thank the Management of Padmasri Dr B V Raju Institute of Technology for their cooperation.

REFERENCES


