Proceedings of the 3rd International Conference on Control, Dynamic Systems, and Robotics (CDSR'16)
Ottawa, Canada – May 9 – 10, 2016
Paper No. 133
DOI: 10.11159/cdsr16.133

Increasing the Safety and Effectiveness of Lower Limb Exoskeletons for Community Use

Jaimie Borisoff
British Columbia Institute of Technology
3700 Willingdon Avenue, Burnaby, BC, Canada
Jaimie_Borisoff@bcit.ca

Extended Abstract

People with significant lower limb disabilities, such as paraplegics due to spinal cord injury, primarily rely on wheelchairs for their everyday mobility needs. Few, if any, technologies exist to provide overground walking capabilities to this population, although powered walking exoskeletons have been recently introduced. These exoskeletons are comprised of an orthosis supporting the user from the feet to torso, battery powered actuators at the hips and knees, and sensors. The technology allows a user with full lower limb paralysis to move from sitting to standing. Further, with the assistance of a walker or crutches, the exoskeleton allows a user to move in a prescribed walking pattern and permits slow ambulation. Although the ReWalk exoskeleton was recently approved for home use [1], other available devices are currently limited to clinical use only, primarily for therapeutic purposes. At home or within the clinic, all exoskeleton use is currently only allowed when supervised by a trained therapist or companion capable of arresting a fall.

In order to determine the mobility potential of exoskeletons in the community, Yang et al. recently noted the importance in distinguishing functional mobility from recreational or exercise-related community walking [1]. Functional mobility necessitates a minimal ambulation speed, which only very few users have demonstrated [1, 2]. However, it also necessitates the ability to negotiate thresholds, doors, and other minor environmental barriers, and the ability to perform activities of daily living and other functional tasks, none of which has been demonstrated. Users interested in only occasional recreational or exercise-related community walking may tolerate slower speeds and other usability limitations; however, safety will still need to be addressed if these devices are to be used independently.

The Rehabilitation Engineering Design Lab, at the British Columbia Institute of Technology and the International Collaboration on Repair Discoveries (ICORD), and collaborators at the University of British Columbia, are interested in developing lower limb exoskeletons for community use. To this end, we have started three activities. First, we surveyed potential end users and therapists to explore their perspectives of exoskeleton technology, reasons for use, and the importance of a variety of device characteristics [3]. The most highly rated reason for exoskeleton use was health benefits, not mobility. Of the design features queried, four had the highest median rating of "very important": minimization of falls risk, comfort, putting on/taking off the device, and cost. Minimizing fall risk, ranked as the most important factor, led to our second research activity: mitigation of exoskeleton falls. We have begun by simulating an exoskeleton falling backwards using OpenSim. Control strategies capable of being performed with existing technology are being studied with the objectives of preventing head impacts and minimizing the velocity of hip impacts.

Finally, we have proposed a new mobility concept that aims to make exoskeleton use easier and more effective for daily community use: the COmbined Mobility Base Orthosis [4, 5]. The design is an integrated exoskeleton-wheelchair that would provide the benefits of standing and walking, while also offering wheelchair-style mobility with dynamic adjustable positioning for performing daily activities. A partnership with an established exoskeleton company has begun to prototype this new mobility concept. In summary, our focus is to help make exoskeletons safer and more useable for practical everyday mobility benefits.

References

[1] A. Yang, P. Asselin, S. Knezevic, S. Kornfeld, and A. M. Spungen, "Assessment of In-Hospital Walking Velocity and Level of Assistance in a Powered Exoskeleton in Persons with Spinal Cord Injury," *Top. Spinal. Cord. Inj. Rehabil.*, vol. 21, pp. 100-109, 2015.

[2] D. R. Louie, J. J. Eng, T. Lam, and Spinal Cord Injury Research Evidence (SCIRE) Research Team, "Gait speed using powered robotic exoskeletons after spinal cord injury: a systematic review and correlational study," *J. Neuroeng Rehabil.*, vol. 12, pp. 82-015-0074-9, 2015.
[3] J. Wolff, C. Parker, J. Borisoff, W. B. Mortenson, and J. Mattie, "A survey of stakeholder perspectives on exoskeleton technology," *J. Neuroeng Rehabil.*, vol. 11, pp. 169-0003-11-169, 2014.
[4] J. F. Borisoff, J. Mattie, and V. Rafer, "Concept proposal for a detachable exoskeleton-wheelchair to improve mobility and health," in *IEEE Int. Conf. Rehabil. Robot.*, vol. 2013, pp. 6650396, 2013.
[5] J. F. Borisoff, J. Mattie, P. W. Rushton, and W. C. Miller, "Perceptions of an integrated exoskeleton-wheelchair mobility concept," in *30th International Seating Symposium*, Vancouver, Canada, 2014.