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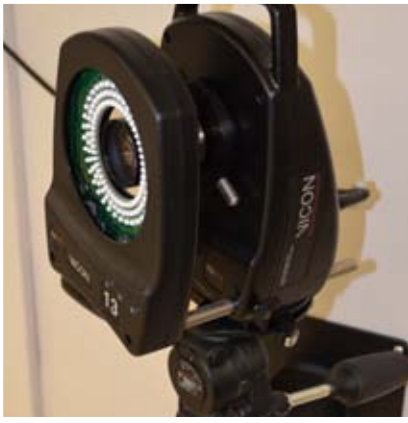
Advanced Platform Technology Center

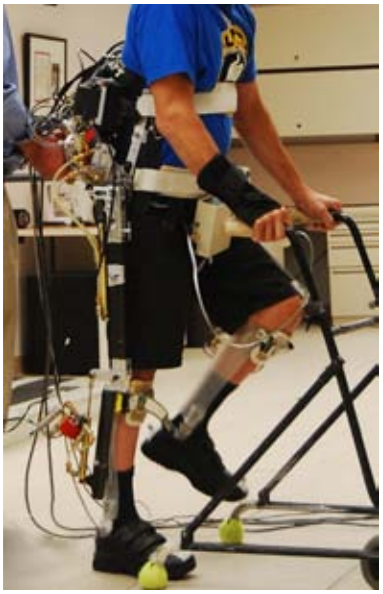
A VA Research Center of Excellence



PROJECT OVERVIEW

Smart bracing to enhance walking and independent mobility

Paralysis, muscle weakness, and lack of coordination are common consequences of injury to the central nervous or musculoskeletal systems. The APT Center continues to focus on improving the design, fabrication and testing of the 'smart' bracing systems that lock and unlock in coordination with voluntary or stimulated muscle contractions to restore or assist independent walking and upright mobility. We are defining a new means to overcome barriers and manage uneven terrain, thus enabling individuals with paralysis to access a wide variety of physical environments.



We developed a first generation prototype neuromechanical gait assist system that combined electrical stimulation to the paralyzed lower extremity muscles with a controllable hydraulic exoskeleton for standing, walking, and stair climbing after paralysis. The system consisted of computer controlled knee and hip mechanisms that allowed the lower extremity joints to either move independently, lock to rest the muscles, or couple one motion to another. The system improved walking stability and posture compared to walking with electrical stimulation alone, and reduced user effort and increased walking speed compared to standard reciprocal braces.

The project is advancing the design to make it self-contained, and suitable for independent use outside the laboratory. Current efforts will reduce the size and weight of the exoskeleton, repackage the electronics and refine the control system to naturally couple hip and knee motion, and damp knee flexion during loading. These improvements should improve foot-floor and step clearance during walking and stair climbing, and provide smoother and more natural gait and stair descent. We also plan to exploit unique ability of the hydraulic system to add small amounts of assistive power to the joints to help complete motions that the stimulated or weakened muscle can't. The potential functional and therapeutic benefits of this new system will be determined in future clinical trials.

APT Center Contributions:

- Mechanical analysis and computer-aided design
- Additive manufacturing, rapid prototyping and 3D Printing
- Design controls and documentation within a quality system to facilitate future commercialization
- Grant management and assistance with intellectual property protection
- Bridge funding, materials, equipment and supplies

Project Funding History:

US Department of Defense, W81XWH-13-1-0099, May 2013 – April 2015
US Department of Veterans Affairs, B0608R, January 2013 – June 2016
US Department of Veterans Affairs, B6026R, July 2008 – September 2010
US Department of Defense, PR043047, May 2005 – April 2009
US Department of Veterans Affairs, B3463R, July 2004 – June 2007

Selected Publications:

"Finite state control of a variable impedance hybrid neuroprosthesis for locomotion after paralysis," T. Bulea, R. Kobetic, M. Audu, J. Schnellenberger, R. Triolo, *IEEE Transactions on Neural Systems and Rehabilitation Engineering,* 21(1):141-151, 2013.

"A variable impedance knee mechanism for controlled stance flexion during pathological gait," T. Bulea, R. Kobetic, C. To, M. Audu, J. Schnellenberger, R. Triolo, *IEEE Transactions on Mechatronics,* 17(5):822-832, 2012.

"Sensor-based stance control with orthosis and functional neuromuscular stimulation for walking after spinal cord injury," C. To, R. Kobetic, T. Bulea, M. Audu, J. Schnellenberger, G. Pinault, R. Triolo, *Journal of Prosthetics and Orthotics*, 24(3):124-132, 2012.

"Stance control knee mechanism for lower extremity support in a hybrid neuroprosthesis," C. To, R. Kobetic, T. Bulea, M. Audu, J. Schnellenberger, G. Pinault, R. Triolo, *Journal of Rehabilitation Research and Development*, 48(7):839-850, 2011.

"Gait evaluation of a novel hip constraint orthosis with implication for walking in paraplegia," M. Audu, C. To, R. Kobetic, R. Triolo. *IEEE Transactions on Neural Systems and Rehabilitation Engineering,* 18(6): 610-618, 2010.

"Development of a hybrid orthosis for standing, walking and stair climbing after spinal cord injury," R. Kobetic, C. To, J. Schnellenberger, M. Audu, T. Bulea, R. Gaudio, S. Tashman, R. Triolo, *Journal of Rehabilitation Research & Development,* 46(3):447-462, 2009.

"Design of a variable constraint hip mechanism for a hybrid neuroprosthesis to restore gait after spinal cord injury," C. To, R. Kobetic, J. Schnellenberger, M. Audu, R. Triolo, *IEEE/ASME Transactions on Mechatronics*, 13(2):197-205, 2008.

The **APT CENTER** is a Department of Veterans Affairs Rehabilitation R&D Center of Excellence that creates novel, cross-cutting technologies for the diagnosis, treatment or study of high priority clinical conditions within a structured framework that facilitates regulatory compliance, dissemination within the rehabilitation community and commercialization by outside manufacturers. Center projects focus on the following: prosthetics and orthotics, health maintenance, neural interface and enabling technologies. The Center has over 30 investigators, engineering and clinical staff, and support services including regulatory affairs, quality systems, project management and grants administration.

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