SPONSOR'S EDITORIAL

Adopting Pattern Recognition Control for Powered Upper-Limb Prostheses

When we move our arms, hands, and fingers, multiple muscles work together to make these motions happen; the human machine typically uses more than one muscle to move, hold, and control each of our upper-limb joints. The concert of muscle activity responsible for every degree of freedom (DOF) is unique. Each of these contributing muscle contractions produces an electrical signature, and the combination of these electrical signals generates a detectable pattern. For example, the pattern of forearm muscle activity for hand opening is different from the pattern of muscle activity for hand closing. Modern microelectronics are capable of sensing these muscle electrical patterns from the skin's surface and associating them with their corresponding DOF in real time. This is what the prosthetics and orthotics community is beginning to know as pattern recognition.

Using pattern recognition to enhance the control of upper-limb myoelectric prostheses has been the topic of some significant science and development for a number of decades. Pattern recognition proposes more intuitive prosthesis control over traditional myoelectric control techniques. With pattern recognition, electrodes placed on the skin over multiple muscle areas, which we often call control sites, can detect the electrical signature patterns of muscle activity as a set of information from all of the sites together. In contrast, traditional myoelectric control only considers the signal amplitude level from one or two electrodes. In other words, traditional myoelectric control is like listening to an orchestra and trying to decipher if the strings section is louder than the horns—while pattern recognition is like hearing what piece of music is being performed.

In a review article for the Winter 2014 edition of *Academy TODAY,* Liberating Technologies Inc., Holliston, Massachusetts, Product Development Director T. Walley Williams III accurately describes pattern recognition as "intuitive myoelectric control." Whereas traditional myoelectrodes collect only the amplitude or strength of the signal, Williams notes that a signal processing system such as pattern recognition "can analyze the signal, select the desired motion, and then control the size of the response. For patients, prosthetists, and therapists, the chief advantage of [pattern recognition] is that it does not require finding the best location for electrode amplifiers, there are no gains to set, and there is no co-contraction problem," Williams writes. "Furthermore, in just one minute, the system can be reset."

Pattern Recognition Is Now a Clinical Reality

Coapt LLC, a Chicago-based company, is committed to developing pattern recognition-control technology for the benefit of upper-limb myoelectric users and their practitioners. Coapt's commercially available Complete Control™ pattern recognition system has made intuitively controlled prostheses a clinical reality. Prior research and development to make this system possible often measured the applicability and potential of more intuitive prosthesis control; however, the real-world benefits of pattern recognition can now be articulated by both patients and practitioners.

Greig Martino, CP, and Brandon Green, DO, medical director, at United Prosthetics, Dorchester, Massachusetts, attest that they believe pattern recognition technology will become the standard of care across the prosthetics and orthotics industry. "Pattern recognition technology has meant a revolution in our upper-extremity patients' level of prosthetic control," they say. "Using pattern recognition from Coapt, even in the hardest-to-fit cases, we can give them a control regime that is intuitive, reliable, and dynamically adjustable, without the need for switching between components. Our patients' performance with pattern recognition is graceful, seamless, and superior to traditional two-site electrodes."

Coapt's pattern recognition technology also has opened new opportunities for how patients can better control myoelectric prostheses. Dave Beachler, CP, of Walter Reed National Military Medical Center, Bethesda, Maryland, says, "With pattern recognition, not only are we able to use naturally occurring voluntary patterns of muscle contractions for ease of controlling the prosthesis, we have been able to use historically unwanted electromyography (EMG) signals from muscles, such as involuntary co-contractions or EMG crossover to be a part of the patient's overall control scheme."

Benefits for Patients

■ **INTUITIVE CONTROL:** With traditional myoelectric control, patients are often required to make nonintuitive, tiresome contractions to command their prostheses. For example, myoelectric prosthesis users may employ wrist extension and flexion contractions to command their prosthetic hand to open or close. With pattern recognition, natural, intuitive control is possible; hand open and close contractions will control the prosthetic hand, and, furthermore, wrist contractions will control the prosthetic wrist, etc. Beachler points out, "Patients reported the muscle contractions associated with pattern recognition systems felt more natural and closer to the actual movement of the prosthesis."

■ **ELIMINATED MODE SWITCHING:** With traditional myo-electric control, individuals often must make cumbersome "switches," such as unnatural co-contractions, to cycle between prosthesis functions. With pattern recognition, users can seamlessly control each of their prostheses' motions without pausing to switch. Glen Lehman, a wounded warrior whose right arm was amputated at the transhumeral level following a grenade bombing in Baghdad, Iraq, was fitted with a pattern recognition controlled prosthetic arm after he found it difficult to control his prosthesis using traditional myoelectric control. He says the technology has "revolutionized" how he controls his myoelectric prosthesis. "It enables me to do six separate functions without having to sequence through to the one I want," he explains. "I don't have any unintended movements, giving me the sense of greater control."

■ **CONTROL CONTRACTIONS CAN BE LIGHT:** Pattern recognition has the benefit of being able to work with low-intensity muscle contractions as needed. This is especially valuable for patients who traditionally had to elicit strong control contractions that tired them out quickly. Coapt's pattern recognition system also provides a better overall ease of use of the prosthesis and promotes increased wear time.

■ **ENHANCED PROPORTIONAL CONTROL:** Because of the difficulty of completely isolating control sites with traditional myoelectric control, much of a patient's ability to modulate the intensity of his or her prosthesis' motor speed is often tuned out of the system (think thresholds that have to be set). With pattern recognition, the system uses full signal information from the patient and relates a wider range of the muscle contraction intensities to prosthesis speeds.

■ **RECALIBRATION:** With traditional myoelectric control, changes in socket fit, patient skin condition, fatigue, etc., can diminish the patient's function with his or her prosthesis. For many of these issues, a repair visit or call to the practitioner is often necessary, resulting in time-consuming prosthesis and software adjustments. Pattern recognition control can adapt to changing conditions by means of recalibration that the patient can do quickly, independently, and efficiently when needed. Ryan Blanck, CPO, LPO, Hanger Clinic Specialty Center, Gig Harbor, Washington, explains, "The ability for patients to have personal ability to monitor and adjust their daily function with the active calibration process of the Coapt [pattern recognition] system is empowering for the patient and adds a new independence for patients that has never previously been available."

Benefits for Practitioners

■ **REDUCED MYOTESTING AND SIMPLIFIED ELECTRODE PLACEMENT:** With pattern recognition, much less time is needed to search for, or precisely place, control site electrodes over isolated muscle signals. This means quicker myotesting for ideal signals, freedom to place electrodes in socket areas that promote fit and comfort, and use of sockets/liners that may be positioned differently upon each donning. In addition, the electrode contacts used for capturing the myoelectric information from the patient's limb can be placed with varying spacing and orientation. With less time spent in the clinic searching for the muscle control sites, the time available for in-clinic functional practice with the prosthesis is increased, thus helping patients adopt their prostheses for increased at-home use.

■ **DON/DOFF FORGIVING:** The pattern recognition benefits of simplified electrode placement and potential for recalibration also lead to systems that can be very forgiving for repeated donnings. The concert of signals that pattern recognition uses can simply be retaken if the electrode contacts are in a slightly different position than when they landed last.

■ **LOWER USE OF SOFTWARE INTERFACES:** One of the misconceptions about pattern recognition is that it is added "technology" and therefore must come with an increased amount of controls to attend to on the computer screen. With Coapt's pattern recognition system, the opposite is true—very little needs to be set up or configured with software on the practitioner's computer. Jacob Townsend, CPO, of Ability Prosthetics and Orthotics, Asheville, North Carolina, notes, "I have been very impressed with the technology both from a practitioner standpoint of being able to learn the system and utilize it for my patient's benefit as well as from the perspective of meeting the patient's needs. It provides the patient a more responsive system to better meet their own needs and goals when compared with what has been available until now."

■ **LESS TIME SPENT WITH SYSTEM ADJUSTMENTS AND RETURN VISITS:** The benefit of prosthesis calibration at any time, the flexibility of myo placement, and the intuition of control all add to continued function for the user—especially in circumstances that would have required a return visit with traditional control, such as a gain adjustment or changes in muscle strength.

Candidates for Upper-Limb Pattern Recognition Control

Coapt is currently helping prosthetic and orthotic practices apply pattern recognition technology to prostheses for patients with shoulder disarticulations and transhumeral and transradial amputations. Both existing myoelectric users and non-users can be considered. Patients with unique myo placement challenges (weak or unbalanced myosignals, poor myo-site isolation, or mode-switching challenges) are often good candidates for pattern recognition when they are not for traditional myoelectric control. This suggests a reachable amputee population that has desired to use myoelectric control but lacks good, traditional myo sites. Blanck of the Hanger Clinic Specialty Center explains, "The Coapt [pattern recognition] system greatly increases consistent and reliable hand, wrist, and elbow function for a group of patients that have had challenges with differentiation."

In summary, pattern recognition provides seamless, intuitive control of multiple degrees of freedom and has proven useful for patients who have difficulty with co-contraction or other mode-switching techniques. In general, any patient desiring intuitive control of their myoelectric prosthesis could benefit from pattern recognition. Many individuals with upper-limb amputations could be considered candidates for pattern recognition control; thus, proper clinical evaluation is important to determine each user's applicability and potential. As research about providing prosthesis users with more intuitive control of their devices continues to evolve, Coapt is dedicated to enhancing intuitive myoelectric control through state-of-the-art pattern recognition technology that benefits both patients and practitioners. ■

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