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TECHNICAL NOTE

Microprocessor technology for powered upper extremity prosthetic control systems

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In recent years, microprocessor technology has invaded the world of prosthetics, revolutionizing the control systems used in powered upper extremity prosthetics.

Ongoing developments in microprocessor technology continue to have a significant impact on the delivery of prosthetic systems. For example, the field-programmable feature of the microprocessor chip allows it to be adapted to the needs of a wide range of wearers. These microprocessors are available in very small packages and have been designed for battery operation at a wide range of voltages using little power. Manufacturers of prosthetic hardware, such as VASI and Liberating Technology, have taken advantage of these developments by creating prosthetic controllers that can be programmed and customized by the prosthetists to meet the user's needs.

The powered upper extremity prosthetic team at the Bloorview MacMillan Children's Centre in Toronto has had extensive experience using MyoMicro, a graphical software programming tool that is compatible with both the Liberating Technology and VASI controllers.

MyoMicro has been superseded by the improved versions of the MyoAssist and MyoWizard which work in tandem with each other. The MyoWizard is used to initially set up the controller with the desired application (for example, a 2-site control system), and the MyoAssist provides the full gamut of virtual control capability, including automatic control site calibration. Provision of instant visual feedback of the user controlling the prosthesis makes the programmable control system a valuable clinical assessment tool.

Over the past few years, numerous wearers have been fitted with programmable control systems and the benefits of this approach will be discussed below.

Selecting a control system for a prosthesis involves assessing the user's functional goals and needs, ability to control multiple myoelectric and mechanical inputs, tolerance of componentry and cost. Regardless of how thorough the clinical team is in making this assessment, the above factors are likely to change over time for the individual.

Programmable control allows the clinical team to change the control system as the needs and abilities of the wearer change, without incurring the cost of purchasing and installing a completely new system.

An example of control system evolution is illustrated by the common clinical practice of using a voluntary-opening or "cookie crusher" control system for children with congenital absences who are under 3 years of age and switching to 2-site myoelectric control when the child is ready. Traditionally, in order to make this switch of control systems, new hardware for the child's prosthesis must be purchased.

As an alternative, using a programmable controller, the change in control system can be accomplished without changing the hardware by merely reprogramming the prosthetic controller. Altering the control system is also common practice in the case of traumatic loss, where the user's tolerance for complex and heavy componentry increases as they become accustomed to their injury and to wearing a prosthesis.

At times there are circumstances where it is necessary to implement control strategies that are not commercially available. Often individuals with special needs require customized control systems because they have difficulty controlling commercially available systems. In the past, this type of customization was expensive and generally avoided by the clinical team. With programmable control, the prosthetic team can create virtually any control scheme that suits a person's unique abilities.

The Bloorview MacMillan Children's Centre powered prosthetics team has also taken advantage of programmable control for users who had been previously fitted with control systems that are no longer commercially available. In many instances, these people have become accustomed to their prostheses since early childhood and changing the control systems may likely have resulted in degradation of control accuracy.

Interference, or noise, pose a significant challenge to successful myoelectric fitting. Interference may come from other muscle in the residual limb, external electrical sources and/or inadvertent co-contraction of the controlling muscle. Programmable control opens the possibility for a number of innovative ways to overcome interference in a myoelectric system. For example, digital filters and time delays can be introduced in the signal path to make the system more selective to the desired signals. The control logic can also be changed. To illustrate, the system can be programmed to ignore a muscle signal if antagonist muscles are active at the same time. Alternatively, the system can react to the first muscle to contract and ignore the second muscle. In some cases, co-contraction itself is the most reliable way for users to communicate their intentions to the system.

The most challenging powered upper extremity fittings persons with higher level losses. These people have the most complex needs but often have the fewest sites for control. The process of choosing the control strategy that is most appropriate and optimizes the control parameters for these users is greatly enhanced by the programmable control approach as it allows them to try a variety of options and the prosthetist to refine the one that best suits them.

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CONCLUSIONS

Microprocessor technology has opened the door to a new world of prosthetics, making powered upper limb prosthetic fitting more versatile and flexible in addressing the varied needs and circumstances of users.

Technological advances have resulted in smaller electronic control boards that offer greater capabilities than those available in the marketplace 5 years ago. Additionally, control systems have become more dependable over the years. The emergence of microprocessors in the prosthetic market allow for multi-control configurations without altering the entire control board. This provides a positive prospect in the world of upper limb prosthetic fittings. A graphical programming software allows for virtual programming of the control board with the desired control scheme, as well as providing the necessary tools to customize the system to suit the user's needs.

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