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Title
Remote Logging of Real-World Usage Data from Upper Limb Myoelectric Pattern Recognition-Controlled Prosthesis Wearers

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Summary
Reliably evaluating prosthesis use and functional performance of patients outside the clinic is always a challenge but necessary for providing effective rehabilitative care. We present a solution to overcome this barrier with the remote logging of real-world prosthesis usage data.

Introduction/ basics
Upper limb myoelectric prosthesis wearers often require hours of rehabilitation as they learn to fully integrate device use into their daily routines. However, one significant challenge for clinicians providing rehabilitative care is evaluating a patient's daily prosthesis use and functional performance outside the clinic. They often rely on in-clinic evaluations and subjective patient feedback that are not necessarily informative or representative of a patient's performance during activities of daily living. There is an obvious need for more objective assessments of patients when they are using their prosthetic device within their own environment. Here, we describe our method of remotely monitoring wearers' daily prosthesis use and performance which includes real-time recordings of a suite of relevant statistical metrics during everyday upper limb myoelectric prosthesis use. Data from patients' daily use can be used to provide insight to the clinician providing rehabilitative care.

Material method; implementation/ process
We implemented data storage capabilities on the hardware of a myoelectric control system that can be used to control any combination of upper limb hand, wrist, and elbow devices. This system executes prosthesis motion control using EMG pattern recognition of user input commands (i.e. coordinated patterns of muscle activity). Users train the control system by completing a motion calibration sequence so that it learns the distinct muscle command

corresponding to each intended motion. The control system is capable of recording each motion output command (motion type and device speed) in addition to other user-initiated events such as each time the user powers on or calibrates their device. It also records electrode lift-off events (i.e. when an electrode displaces from the skin surface). To make efficient use of storage space, the system logs a wide range of relevant statistical data on the daily prosthesis use and functional performance.

Results

To date, we have collected prosthetic use and performance logs over a two-week period from eight individuals with upper limb difference (6 Transradial (TR), 2 Transhumeral (TH)) who are existing myoelectric pattern recognition control system wearers.

Figure 1 shows a some of the usage statistics for each wearer, including prosthesis wear-time and the frequency of user-initiated calibration events. Other valuable usage frequency metrics were analyzed including output motion (i.e. number of times each prosthetic motion is user-commanded), electrode lift-off (i.e. number of times an EMG electrode displaces from the skin surface) and output motion speed (i.e. distribution of controller output speeds for each motion).

Figure 2 shows representative plots of an individual (Transradial) prosthesis wearer. (left) Plot of commanded motion frequency (expressed as the proportion of controller output motions for 5-minute intervals of regular prosthesis use) showing user preferences towards hand open and wrist supinate motions. (middle) Plot of commanded motion speed frequency (expressed as a distribution of controller output speeds for 5-minute intervals) indicating user preferences towards slower movement speeds when operating the prosthetic device. (right) Plot of electrode lift-off frequency showing lift-off events that are consistently detected which could indicate a potential issue with the user’s myoelectric interface.

Discussion/ conclusion; conclusion for the practice

Many myoelectric prosthesis wearers require continuous clinical and technical support long after prosthesis delivery and in-clinic care. The sample of prosthetic usage and performance metrics shared are simple yet informative. Access to wearers’ data can help clinicians diagnose functional issues, track rehabilitation progress and develop specific, effective rehabilitative care. Our long-term goal is to connect remotely-logged patient performance data to clinical teams for integration into their prosthetic care. We believe a portal of analyzed data will lead to more effective rehabilitation and better improvement in functional outcomes which will increase daily prosthesis wear-time, decrease the frequency at which users need to calibrate their device. We anticipate this will also increase satisfaction and, ultimately, make it less likely that prosthesis wearers abandon their device; optimizing rehabilitation outcomes for myoelectric pattern recognition-controlled prosthesis wearers.

References

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Image: Figure 1 - Usage Statistics Table_257_257.jpg

	TR1	TR2	TR3	TR4	TR5	TR6	TH1	TH2	AVG.
Years using Pattern Recognition	2 yrs. 9 mos.	1 yr. 6 mos.	2 yrs. 3 mos.	**8 mos.**	4 yrs. 8 mos.	**6 yrs. 2 mos.**	1 yr. 4 mos.	6 yrs.	**3 yrs. 2 mos.**
Total Wear Time (hrs)	6.9	50.9	25.9	**125.0**	**4.0**	124.4	66.4	9.6	**51.6**
Avg. Wear Time per Power On (min)	25.8	70.8	64.8	**241.8**	**21.6**	147.6	52.2	28.8	**81.8**
# of Calibrations	16	39	10	11	**3**	34	**85**	6	**25.5**
% of Motion Sequence Calibrations	94%	30.8%	90%	55%	**100%**	**100%**	**26%**	**100%**	**74.5%**
Avg. # of Calibrations per Power On	0.64	**0.89**	0.30	0.30	**0.17**	0.31	0.75	0.18	**0.44**
% of Power On without Calibrating	80%	**75%**	82%	**89%**	**89%**	**75%**	82%	82%	**81.8%**

Image: Figure 2 - Performance Statistics_258_258.jpg