Lower Limb Prosthesis Control:
An abstraction of Stability from Pattern Recognition Algorithms

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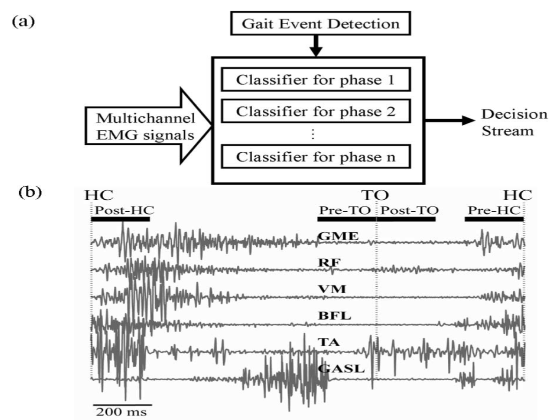
Surface EMG pattern recognition for lower limb prosthesis control has been an area of research recently investigated by biomedical engineers concerned with pushing forward prosthesis technology. The arm has received considerable interest as a site for further development of prosthetic devices and this research has proven very useful in extracting user intent. [1] Prostheses that can interpret user intent through surface EMG signals would be invaluable to amputee stability and allow for further development of lower limb prostheses, which have received less interest in comparison to the interfacing options of upper extremity devices.

Recently, the development of Neural Machine Interface (NMI) technology has created a bridge between assistive technology and efferent nerve action. The need to create a pattern recognition (PR) algorithm which can be utilized in real time must be fulfilled before complete implementation can proceed. At the moment, the forefront PR algorithm requires a complete gait cycle which may be too long when quick reaction is necessary. Huang *et al* [2]. The muscle action which conveys intent should be interpreted by the algorithm in a 140ms window. This would advance lower limb prosthesis technology and benefit countless lower limb amputees.

A study done by Dr. He Huang involved sixteen channels of surface electrodes to decipher muscle action through a gait cycle. The sixteen channels represent muscles observed, including: *gluteus maximus, gluteus medius, sartorius, rectus femoris, vastus lasteralis, vastus medialis, gracilis, biceps femoris long head, semitendinosus, biceps femoris short head, tibialis anterior, peroneus longus, gastrocnemius lateral head, gastrocnemius medial head, soleus, and extensor digitorum brevis*. The study was taken to determine a phase-dependent PR algorithm with high classification accuracy for various tasks a leg may be expected to compensate for. The results of this study yield a great amount of hope for further development of lower extremity prostheses by achieving narrow margins of error within 5-10% dependent on phase. These phases were chosen as post-heel contact, pre-toe off, post-toe off, and pre-heel contact. It is important to note that there can be overlap of the phases included in an individuals gait. The classifier for phase was analyzed using a confusion matrix for a calculation of confidence for each task. This clarifies results and shows that certain tasks require a more robust PR algorithm.

The task receiving the lowest confidence level was 'Level Walking'. This may seem counterintuitive due to the necessity of this task in everyday life, but that may very well be the reason it is difficult to interpret. When the subject concentrates on the task, the EMG returns a stronger signal which yields a higher confidence level. If the subject has little difficulty accomplishing the task, the signal could be lost in ambient noise.



At present, locomotion modes for lower limb prostheses must be manually configured to compensate for various tasks. Once algorithms which correctly identify stability needs have been produced, progress in NMI prosthetic devices will flourish. With advancement of pattern recognition and improvement of sampling windows there will be far more capabilities involving multiple target control. Multisensor fusion, a PR strategy encompassing multiple inputs is noted to be a likely solution to sensor uncertainty. Progress in this field will advance safety in lower limb prostheses.

References:

[1] Huang *et al.* An Analysis of EMG electrode configuration for targeted muslce reinnervation based neural machine interface.IEEE Trans. Neural Syst. Rehabit. Eng. 2008 Feb.; 16(1) 37-45.
[2] Huang *et al.* A strategy for Identifying Locomotion Modes Using Surface Electromyography. IEEE Transactions on Biomed. Eng. 2009 January; 56(1) 65-73.[3] Hawamdeh *et al.* Assessment of anxiety and depression after lower limb amputation in Jordanian patients. Neuropsychiatr Dis Treat. 2008 June; 4(3): 627–633.