Localization of motor units using surface electrodes

The contractions of our muscles change the electric potential on the skin surface. For individual motor units, this change has a unique distribution which is used to estimate their position.

Our muscles are made up of often hundreds of individual motor units, and the contraction of each motor unit creates an electric signal. As all these signals travel to skin surface, they fade and mix with each other. This project had two main obstacles to overcome; separating individual motor units from a sea of recorded muscle activity, and to explain how motor units at different positions affect the surface signal differently.

Knowing the location of motor units is important for several areas such as neurology, prosthetic control, and monitoring rehabilitation. If the surface signals can be matched properly with muscles at different locations, then better and more natural control of prosthetic limbs could be made. After an injury like stroke, many patients lose the ability to control motor units in some muscles. By mapping the location of motor units to specific muscles, the amount of motor units can serve as a measure of the recovery of those muscles. This could then become an additional assessment tool to make sure rehabilitation is effective.

Specialized software and algorithms managed to successfully decompose raw signals from surface electrodes into individual motor units. Two models were then devised for estimating the position of motor units based on one principle: Motor units near the skin surface are much closer to some electrodes and far away from others, the signal strength therefore has a sharp peak at that point. Motor units deep into the body however, are relatively far away from all electrodes. This means the signal peak is not as well defined and more uniformly distributed. The first model was derived from a previous paper by Roeleveld et al, while the second model expanded upon the first by taking into account different conductivities in muscle and fat. The models are promising, but further testing and calibration is needed to determine the reliability of the results.

Studying motor units has long been done with electrodes inside muscles, using needles or wires. These approaches don’t need localization techniques as long as you don’t lose track of the position of the electrode inside the muscle. However a non-invasive approach using electrodes on the skin surface is much more preferable to the discomfort and risks of damage and infection involved with electrodes penetrating the skin. It is however more difficult due to the decreasing strength of the signal as it travels to the surface and mixes with other sources.