Analysis of EMG signals during posture maintenance

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Introduction

The research focuses on the reflex activity of shoulder muscles during posture control. For example, to maintain a straight course when riding your bike in stormy weather, reflexes of your muscles constantly suppress force disturbances caused by side wind.

Background information

1. Muscle spindles measure the change of length of the muscle caused by force disturbances

2. Muscle spindles send a signal to the spinal cord

3. The spinal cord sends an activation signal to the muscle (i.e. reflexive feedback) to restore the posture

4. This reflex activity is measured with Electromyography (EMG)

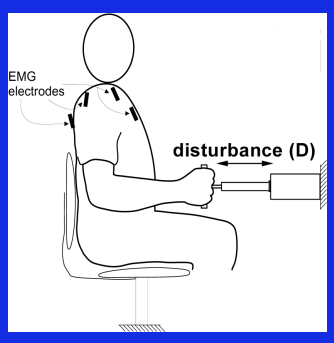
So far, EMG signals were unusable due to poor signal to noise ratio (SNR). A frequency response function (FRF) of the neuromusculoskeleton (NMS) system was determined, based on hand force and hand position measurements.

Goal

The goal is to improve the poor SNR of the EMG, so that a newly developed EMG model can be used to validate the NMS model.

Methods

Unpredictable force disturbances in horizontal direction are applied to the subject. The subject is asked to minimize the position deviations.

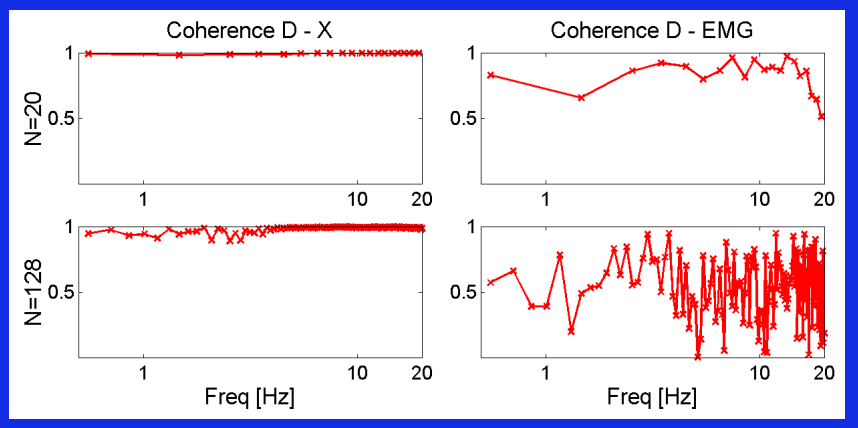


To distinguish reflex activity from the noisy EMG signal, the former has to be intensified. Therefore, two types of disturbances have been applied:

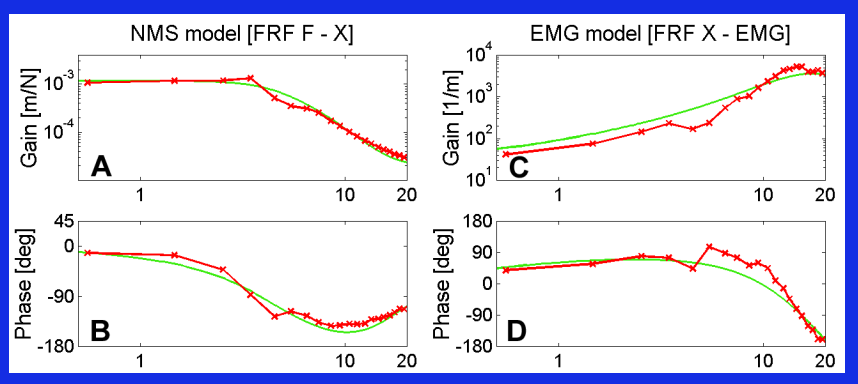
1. wide band (WB) disturbances, with reduced number (N) of sine waves, to increase the power per sine wave.

2. narrow band (NB) disturbances; it has been found that with NB disturbances the spindle activity is increased (Van der Helm et al., 2002).

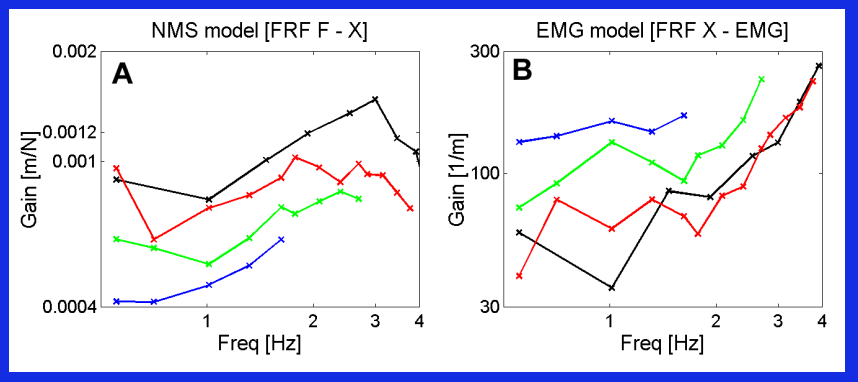
Results



Coherences between disturbance (D) and hand position (X) are always high. Coherences between disturbance and EMG are substantially improved for lower N in the WB signal, meaning an improved SNR.
For NB disturbances the coherences between disturbance and position / EMG are both high (not shown).



Figures A-B (red lines) are Bode plots of *measured* FRF between hand force (F) and position, suggesting a second order system. These lines coincide with the green lines which represent the FRF of *modeled* data of the NMS model.
Figures C-D (red lines) are Bode plots of *measured* FRF between position and EMG. These lines also coincide with the green lines representing the FRF of *modeled* data of the EMG model.



The gain of the FRF between force and position decreases in Fig. A for narrower bandwidths (more spindle activity → system stiffer). Meanwhile the gain of the FRF between position and EMG increases in Fig. B (more spindle activity).

Conclusions and recommendations

1. It is possible to substantially improve the SNR in EMG signals by either reducing N or by narrowing the bandwidth.

2. The EMG *qualitatively* validates the higher level of spindle activity for narrower bandwidths as already seen in the FRF between force and position.

3. Measured FRFs between force and position coincide with modeled data of NMS model. Measured FRF between position and EMG coincide with modeled data of EMG model.

We recommend further research to *quantitatively* validate the measured EMG, yielding more results and insights.