EMG-TO-TORQUE DYNAMIC RELATIONSHIP FOR ELBOW CONSTANT ANGLE CONTRACTIONS

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ABSTRACT

The purpose of this work was to determine the optimal EMG-torque relationship using four different EMG processors in conjunction with different system identification (ID) techniques for dynamically torque varying elbow constant angle contractions. Comparing predicted torque with actual elbow torque, it was found that either multiple EMG channels or EMG signal whitening lead to the best relationship. The choice of the system ID model had limited effect on performance.

INTRODUCTION

EMG amplitude estimation is used in several biomedical applications such as prosthesis control and evaluation of muscle activity. Different kinds of advanced EMG processors have been proposed to improve the EMG signal-to-noise ratio (SNR) to provide a more reliable amplitude estimate [1]. The purpose of this work was to determine the optimal EMG-torque dynamic relationship using these advanced processors in conjunction with different system ID techniques. The study was limited to dynamically torque varying elbow constant angle contractions.

METHODS

The data used in this study were obtained during an experiment described in detail in [2]. Briefly, subjects were firmly seated in a Biodex chair and were asked to exert a dynamically varying elbow torque indicated by a visual signal on a computer screen, for a periods of 30 seconds at a maximum of 50% of their MVC. Sixteen subjects participated in the experiment. Eight EMG surface electrodes (four on the biceps and four on the triceps) were placed on the subject arm to acquire EMG signals. Four different EMG processors [single channel (one per biceps/triceps), multiple channels (four per biceps/triceps), single channel with adaptive whitening and multiple channels with adaptive whitening] and three different system ID techniques [an Auto Regressive with eXogenous inputs (ARX) model which includes a non zero operating point, an ARX model without an operating point and Output Error (OE) model which integrates the operating point in the ID process] were compared to determine the best EMG-torque dynamic relationship among the 12 possible combinations. The optimal number of poles and zeroes were also investigated.

RESULTS

The best EMG-torque relationship was determined by comparing actual elbow torques to those predicted from the models described above. Performance of the predicted torque was based on the percent variance accounted for (%VAF). Results are shown in Table I.

	EMG Processors			
Models	**single**	**mul.**	**single white**	**mul. white**
ARX (operating point)	86.9	90.4	89.2	90.7
ARX (without operating point)	87.9	91.8	90.6	90.6
OE (standard MatLab starting point and with operating point ID)	90.2	93.3	91.5	90.8

Table I. %VAF for all models and all processors using the best model orders.

DISCUSSION & CONCLUSIONS

Results show that multiple channel and/or whitened EMG processors increased the %VAF. The optimal orders for all models ranged from 1–2 for the numerator and from 3–6 for the denominator. The use of the OE model instead of the ARX model was more beneficial for the single channel unwhitened processor. This result can be explained by the fact that the signal from a single unwhitened processor is noisier and the ARX model puts more weight at higher frequencies. The higher performance of the multiple channel and/or whitened EMG processors may be attributed to their ability to reduce the stochastic term in the identification process. We are currently investigating the effect of tracking movement bandwidth on the performance of the model and the impact of chosing different starting points in the OE optimization.

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