ENEL 563 Biomedical Signal Analysis

Project on Analysis of the Relationship Between Parameters of the EMG Signal and Muscular Force

1 Objectives

- Characterize the level of activity in EMG signals.
- Analyze the relationship between parameters of the EMG signal and muscular force.

2 Specific Tasks

1. Get EMG signals related to various levels of muscular activity or force. You may use the data files EMGforce.txt and EMGforce2.txt as well as the program EMGforce.m from

   `http://www2.enel.ucalgary.ca/People/Ranga/enel563/SIGNAL_DATA_FILES/`

   The sampling rate is 2000 Hz per channel.

2. Normalize the force signal such that the minimum value is zero and the maximum value (corresponding to the maximum voluntary contraction or MVC) is 100. Filter the force signal to remove noise and artifacts (see Chapter 3 of the textbook for filtering methods). Plot the EMG signal (in mV) and normalized force (in %MVC) against the time axis.

3. Develop MATLAB code for automatic identification of portions (segments) corresponding to each level of contraction within which the force remains near the corresponding peak values.

4. For each segment of the EMG signal identified as above, compute at least four suitable parameters (see Chapters 3 and 5). Ensure that your list of EMG features includes the following: RMS value, zero-crossing rate, and turns count. Compute also the average force (in %MVC) for each segment.

5. Plot the values of the various parameters versus force in %MVC. Label the axes with the appropriate units. Analyze the results in terms of statistical variation of the parameters in relation to force.

6. Using the `polyfit` function in MATLAB, obtain a straight-line (linear) fit to represent the variation of each EMG parameter versus force. Use `polyval` to evaluate the values of the dependent variable given by the model for the available values of the independent variable. Superimpose the linear models (straight-line fits) obtained on the plots of the parameters in the preceding step. Analyze the results.

7. Compute the correlation coefficient, r, with r^2 given by the formula

$$r^2 = \frac{\left[\sum_{n=1}^{n=N} \ x(n)\, y(n) - N\, \bar{x}\, \bar{y}\right]^2}{\left[\sum_{n=1}^{n=N} \ x^2(n) - N\, \bar{x}^2\right] \, \left[\sum_{n=1}^{n=N} \ y^2(n) - N\, \bar{y}^2\right]}\,, \tag{1}$$

   where N is the number of samples of x or y representing each of the EMG parameters or force; $\bar{x}$ is the mean of x. Using r, analyze the goodness of fit for each parameter and discuss the appropriateness of the linear model. See

   http://mathworld.wolfram.com/CorrelationCoefficient.html

   for details on linear least-squares fitting and the correlation coefficient. See Chapter 5 of the textbook for related examples.

8. Tabulate the parameters of the linear model and r for each of the EMG parameters. Analyze the results and describe your findings.

9. Perform all of the above steps with both of the EMG signal provided. Analyze and compare the results.

See figures in the textbook for examples on how to illustrate signals before and after filtering, how to label plots with the results of detection or segmentation, how to show plots of features belonging to different types of signals, and how to evaluate the results of classification.

Use graphs to explain your results as necessary. Always label the axes of your graphs and show the proper units. If the units of a variable are not calibrated or are unknown, label the corresponding axis as “arbitrary units” or “AU”.