The intention of this article is to be a well-defined list of tasks that must be completed in order for the artificial neural network signal processing technique for Limbitless Solutions to be built. Each task is described and given sources for reference to some degree. As some tasks are more challenging than others, programmers are encouraged to break down their own work into parts like this and delegate if possible:

The intention of this full project will be so that the child who is to be given the arm can record sample data from their arm and send it to Limbitless Solutions for training before the child has the arm. We will receive data from the child for each arm movement they would like the artificial neural network to test for, and a set of silence data. Each child will probably need to record their movements several times, in order to have enough data for training the network.

Once data from the childs arm is obtained, the network is trained remotely using the saved waveform data. This will potentially give a very close reading to what training the arm with the child would be like.

The placement for the EMG must be at very similar locations each time the child uses the arm, but this will probably allow for multiple degrees of freedom from one EMG.

Tasks:

The ANN: DIFFICULT LEVEL \*\*\*\*\*

Multiple outputs.

The existing code for the artificial neural network we have must be edited to provide for multiple outputs. For information on the artificial neural networks, see the chapter in [www.natureofcode.com](http://www.natureofcode.com)

Backpropagation and training:

The existing artificial neural network uses the backpropagation technique for training already, but this will have to be altered to account for multiple outputs. I’d recommend using the graphing technique Daniel Shiffman did when showing the training of the algorithm, with multiple graphs

Activation Functions

There is already code for a sigmoid activation function but we will possibly need a linear activation function as well. This should be very easy.

The Telegen-Kaiser Energy Operator: LEVEL OF DIFFICULTY \*\*\*

The Telegen Energy Operator is an energy measuring function of a wave that can be used to find parts of a signal that actually contain information. For this we will need a function that computes the discrete Telegen Energy Operator:

Y = X2[n] – X[n-1]\*X[n+1]

For a given array of length three or more.

See page 37 of Classiﬁcation of surface electromyographic signals for control of upper limb virtual prosthesis using time-domain features.

Also see Signal Processing using the Teager Energy Operator and Other Nonlinear Operators

Segmentation: DIFFICULTY LEVEL \*\*\*

Given an array of waveform input data for .5 seconds (500 ms) break that data up by applying the telegen energy operator to it and keeping the most useful 200 ms. Split that 200 ms into 5 segments of 40 ms for ANN classification.

See Classification of surface electromyographic signals for control of upper limb virtual prosthesis using time-domain features

Input Data Gathering: DIFF LEVEL \*\*

Mean Abs Value

Compute the mean absolute value of a given data set of 40 ms

Mean Abs Value Slope

Compute the mean absolute value slope of a given data set of 40 ms

Zero Crss Counter

Compute the number of times the input data crosses the 0 value line with a given threshold of 1E-6 for noise reduction

Count Slope Sign Changes

Count number of times the slope changes sign during 40ms interval

Waveform Length

Compute the waveform length, (See the Yes Article/ Classiﬁcation of EMG signals using artiﬁcial neural networks for virtual hand prosthesis control)