Electromyography control of robotic systems

Denis Griaznov <denis.griaznov@tul.cz>, Ing. Jan Koprnický, Ph.D.

This work describes research of myoelectric interfaces and their application for controlling robotic systems. Hand gesture data collection software has been created. The neural network was designed and trained to recognize various gestures. The accuracy was 0.992 for four gestures and 0.959 for seven gestures. The prototype of myoelectric signals controlled robot with two degrees of freedom was created. Wireless direct control via bluetooth was implemented.

Keywords: electromyography, Myo Armband, robotic control, neural networks

Introduction

The ultimate goal of the work is the creation of a robotic system that will be controlled by EMG signals using Myo Armband. Research motivation is based on two factors. First, such systems have proven their applicability in important areas. To date, myoelectric sensors have been successfully used in hand prosthetics [1. 2]. Secondly, modern technology allows to develop a similar system and achieve better performance. Largely due to advances in machine learning and neural networks [3].

Methodology

The data structure in experiments related to EMG is similar to other biological signals. So, it’s very difficult to build an ordinary mathematical model and understand significant features. But machine learning models are well suited for such tasks. Therefore, machine learning was used in this work.

The main method used to recognize gestures was Long-term short-term memory (LSTM). LSTM is a form of neural network architecture that is great for time series analysis [3]. The network consists of LSTM modules. The LSTM module is a recurrent network module that can store values for both short and long periods of time. LSTM networks do a good job with speech recognition, classification of biological signals, recognition of human activity.

For better results, the data needs preprocessing. Original EMG signal has fast large differences of values. At first absolute data values were taken. At second for its approximation Savitzkiy-Goley filter with 9 points and 2nd polynom order has been selected.

Data for 7 different gestures was collected through Arduino. Figure 1 shows their images and names. It is necessary to select 4 gestures from 7 to control the robot. There were Fist, Wave In, Wave Out and Pointer.

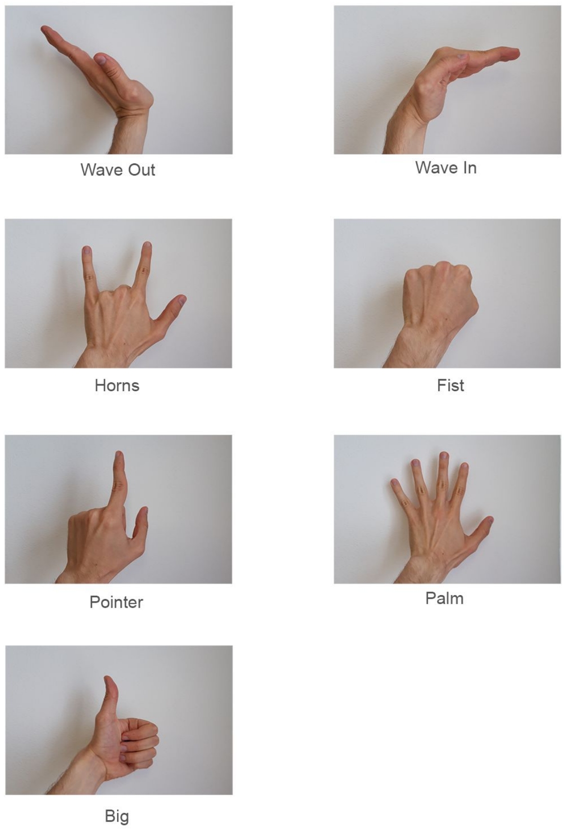

Figure 1: Used gestures.

As the main model the deep recurrent neural network model was used, including two internal LSTM layers of 50 units and one internal normal layer of 64 neurons (Figure 2). For each of 8 sensors 8 latest measurements were input (64 units). To avoid overfitting, a dropout of 0.2 was used on the LSTM layers. This means that every epoch, 0.2 of randomly selected layer neurons are disabled.

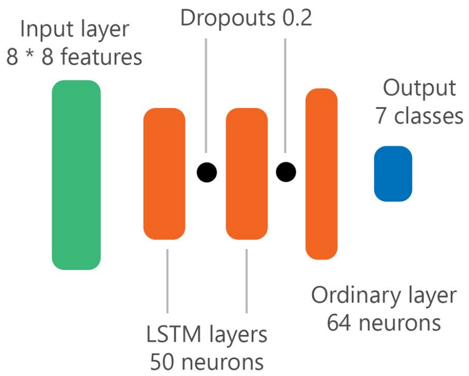

Figure 2: LSTM model architecture.

Results and discussion

The LSTM-based model used a dataset with 7500 samples divided into 7 classes. The validation part was 0.2 of all samples. The model corresponded to 50 train epochs. It showed an accuracy of about 0.959 on validation samples. Model fitting is shown in Figure 3.

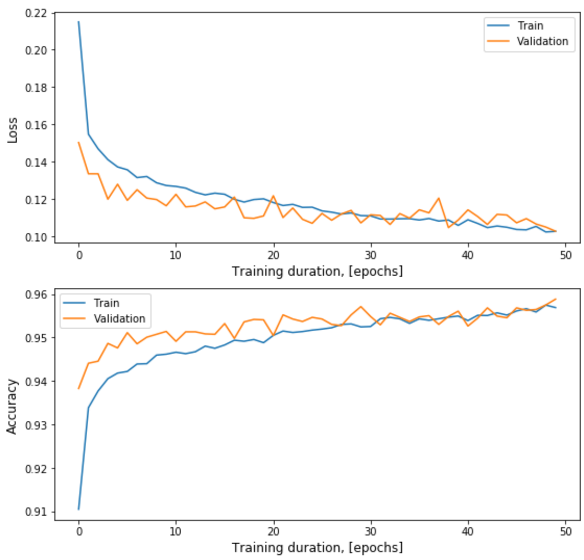

Figure 3: Model fitting.

In addition to the Myo Armband, there are two Micro Servo GG SG90 servo motors and the WeMos D1 Mini board in the plant. The one servomotor stands on the second one. In this way two freedom degrees and four possible movement kinds for control were obtained. To control the robot, the same model was used for 4 gestures. Its accuracy was 0.992.

Conclusions

The results of the gesture recognition models were satisfactory. The model that was used to control the robot is further improved by internal post-processing of the results on the microcontroller.

If the data is normalized separately for each moment in time, the resulting matrix can be visualized as a single-color image. Then the images of the same class will have some similar elements located in different places. Convolutional Neural Network can be used, reducing the task to the classification of images.

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