# Hand Gesture Recognition Based on Electromyography Signals and Deep Learning Techniques

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***Abstract*—Hand gesture recognition based on electromyography (EMG) signals is a challenging approach for developing natural and intuitive human-computer interfaces. In this paper, a hand gesture recognition system will be proposed that uses deep learning techniques, specifically a convolutional neural network (CNN) and a long short-term memory (LSTM) by merging them into one architecture called CNN+LSTM model. CNN is used to extract relevant features from the EMG signals, while the LSTM captures the temporal dynamics of the gestures. The proposed model is a fusion technique that combines the strengths of CNN and LSTM. Therefore, incorporating CNN+LSTM would be crucial in improving the accuracy of the model. The proposed system was trained and evaluated on two datasets publicly available. The first one, DualMyo, includes EMG signals recorded from one subject performing 8 different hand gestures, with each class of gestures recorded 110 times. The second dataset was collected from 36 subjects performing 8 different hand gestures. Results demonstrate that our proposed system achieved outstanding performance, with an average recognition accuracy for both data sets of approximately 99% for the DualMyo and about 97% for the second. To tackle the testing time issue, we introduce a second model that incorporates cascading CNN and max pooling layers, achieving a substantial reduction rate of 1/20 compared to the first model in testing time without significantly compromising recognition accuracy significantly, ultimately achieving the shortest testing time with good accuracy compared to the related methods. Experimental results demonstrate the efficacy of this approach, making it suitable for real-time applications in gesture-controlled systems.**

***Keywords*—Hand gesture recognition, EMG (signal electromyography), CNN (convolutional neural network), LSTM (long short-term memory)**

## I. Introduction

The EMG signal is a biomedical signal that measures electrical activity produced by skeletal muscles. The EMG has been employed for many purposes including the estimation of finger motions, gesture recognition, diagnosis of neuromuscular illnesses and control systems such as robots and prosthetics. The development of relevant machine-assisted systems that promote the autonomy of individuals with special needs can be facilitated using EMG signals in conjunction with efficient gesture recognition [1].

Hand gesture recognition based on EMG signals is a challenging research area in human-computer interaction (HCI) with various applications, including sign language recognition, prosthetic control, and virtual reality. Hand gesture recognition based on EMG signal has garnered significant attention in the field of assistive technology, particularly for individuals with limb amputations. Myoelectric prosthetic devices typically operate by analyzing and categorizing the recorded EMG signals, thereby enabling the synthesis of desired hand gestures [2]. Traditional approaches to hand gesture recognition, such as vision-based methods, have limitations such as being affected by lighting conditions and occlusion [3].

Utilizing Machine Learning (ML) for EMG-based gesture recognition is a popular yet challenging endeavor. It necessitates diverse and accurately labeled EMG datasets, considering variable EMG signals influenced by factors like fatigue and electrode placement. Moreover, meaningful feature extraction from raw signals, the selection of appropriate ML algorithms or neural architectures, optimal hyperparameter configuration, noise/artifact handling, user-specific model adaptation, real-time processing, intent recognition, and ethical considerations all come into play.

Deep learning is a subset of ML algorithms, particularly CNNs and Recurrent Neural Networks (RNNs), have achieved remarkable success in various applications, including image and speech recognition. One distinguishing factor of deep learning techniques, compared to conventional ML approaches, is their integration of feature extraction as part of the model construction, thereby eliminating the need for manually crafted features [4]. In recent years, deep learning has also been applied to EMG-based hand gesture recognition. A deep learning-based approach offers the potential to automatically learn features that are important for recognizing hand gestures from raw EMG signals. Therefore, the combination of EMG signals and deep learning techniques holds great promise for

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