Chapter VI

A Recurrent Probabilistic Neural Network for EMG Pattern Recognition

Toshio Tsuji, Hiroshima University, Japan
Nan Bu, Hiroshima University, Japan
Osamu Fukuda, National Institute of Advanced Industrial Science and Technology, Japan

Abstract

In the field of pattern recognition, probabilistic neural networks (PNNs) have been proven as an important classifier. For pattern recognition of EMG signals, the characteristics usually used are: (1) amplitude, (2) frequency, and (3) space. However, significant temporal characteristic exists in the transient and non-stationary EMG signals, which cannot be considered by traditional PNNs. In this article, a recurrent PNN, called
A Recurrent Probabilistic Neural Network for EMG Pattern Recognition

A recurrent log-linearized Gaussian mixture network (R-LLGMN), is introduced for EMG pattern recognition, with the emphasis on utilizing temporal characteristics. The structure of R-LLGMN is based on the algorithm of a hidden Markov model (HMM), which is a routinely used technique for modeling stochastic time series. Since R-LLGMN inherits advantages from both HMM and neural computation, it is expected to have higher representation ability and show better performance when dealing with time series like EMG signals. Experimental results show that R-LLGMN can achieve high discriminant accuracy in EMG pattern recognition.

Introduction

Electromyographic (EMG) signals provide information about neuromuscular activities and have been recognized as efficient and promising resources for human-machine interface (HMI) used for the rehabilitation of people with mobility limitations and those with severe neuromuscular impairment. Typically, a pattern recognition process is applied to translate EMG signals into control commands for the HMIs, such as powered prostheses and functional electrical stimulation devices (Englehart et al., 2001; Fukuda et al., 2003; Hudgins et al., 1993; Lusted & Knapp, 1996). Generally speaking, a successful EMG pattern recognition technique relies on two principle elements: a pattern classifier with reliable discrimination accuracy and efficient representation of EMG feature characteristics.

Probabilistic neural networks (PNNs) developed in the field of pattern recognition make a decision according to the probability density distribution of patterns in the feature space (Specht, 1990; Tsuji et al., 1999). Since PNNs integrate statistical models into the neural networks’ architecture as prior knowledge, outstanding performance has been reported. Recently, PNNs have become widely accepted as important classifiers and have been proven to be efficient, especially for complicated problems such as pattern recognition of bioelectric signals.

For EMG pattern recognition using PNNs, the feature characteristics usually used include: (1) amplitude, (2) frequency, and (3) spatial information from multiple channels of EMG signals. However, significant temporal characteristics exist in the transient and non-stationary EMG signals, which cannot be considered by the traditional PNNs based on static stochastic models, and, in some cases, temporal characteristics could be the only clues for reliable recognition. This chapter introduces a recurrent PNN called recurrent log-linearized Gaussian mixture network (R-LLGMN) (Tsuji et al., 2003) into EMG pattern recognition,