Machine Learning Approaches for Signal Processing

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Abstract

In this paper, existing machine learning techniques for signal processing are reviewed and presented. The machine learning techniques used in processing of signals for detection of stress, detection of network intrusion, design of antenna, QRS detection and quantification and recognition of gestures are discussed and presented. The use of the machine learning in signal processing has reinforced its need in futuristic smart machines or robots for domestic and industrial purposes which validates their importance in current scenario.

Keywords: machine learning, signal processing, smart machines.

1. Introduction

The future is going to be a world which will be surrounded by smart machines and this need can be fulfilled only when the machines can learn the tasks that are required to be performed in domestic and industrial environments. The researchers are continuously working to develop machine learning techniques for all kind of applications. One of the important application which is carrying a big scope in future era is processing of signals in different areas. These areas includes biomedical signals and images of organs of patients, sensor data of firefighters and military personnel in real time situations, health data of sports person in fields, images from satellites and images of deep space and any other sensory data available for processing.

The machines that will process the available sensory data must undergo learning processes to provide the accurate results. In [1], for the designing of antennas, the applications of machine learning is presented. Machine learning has been used with signal processing in [2] to recognize the gestures which are dynamic in nature. The biological signals have been used for signal processing along with machine learning to detect the stress level of a person [3]. In [4], Many models for machine learning have been utilized for intruder detection in network traffic. The QRS fragmentation has been detected and quantized using machine learning in [5].

This article is organized in four sections. The different machine learning schemes used for processing of signals have been discussed and presented in Section 2. The conclusion of the article is presented in Section 3.

2. Machine Learning Schemes for Processing of Signals

(a) For Antenna Design and Processing of Radar Signals

In [1], machine learning algorithms for the design of antennas and for the processing of the signals generated in Radar are reviewed and presented. Using machine learning algorithms, the size of the patch of the antenna can be determined in a more fast manner than an EM simulator if resonant frequency of the antenna under design process is known [1]. Similarly, other parameters of the antenna can be determined using machine learning algorithms. In [1], it was illustrated that neural networks are the potential algorithms which can be used to implement machine learning techniques. The general structure that is used to represent neural networks is presented in Figure 1.
The recognition of gestures with machine learning and signal processing technique has been proposed in [2]. In this method, Wi-Fi signals have been employed to detect and identify different gestures. The features of the Wi-Fi signal were extracted using discrete wavelet transform (DWT). To classify and recognize different dynamic gestures, the extracted features are then fed to a support vector machine (SVM). It was observed that nine out of ten dynamic gestures were recognized which provided the recognition rate of 94.8%. In this schemes, small set of training data was used for training purpose [2].

(c) For Biomedical Signals

To detect the stress level of a person, signal processing along with machine learning has been employed in [3]. The different data from biological point of view, such as galvanic skin response of foot and hands, EMG signal, heart rate and respiration of different persons at different places and situations during driving mode was utilized. The block diagram of the method used in [3] is illustrated in Figure 2.

The biological data of 7 drivers which is available on PHYSIONET database was employed. This biological data was segmented for different time intervals and their features in statistical form were extracted. The extracted features were further fed to a classifier to rate the stress as low-level, medium-level and high-level stress [3].

In [5], phase-rectified signal averaging (PRSA) has been used along with variational mode decomposition (VMD) to perform the segmentation and feature extraction of the ECG signals. Further, these features were fed to classifiers for performance comparison [5]. In this scheme, fQRS score was used to accurately detect and quantify the fragmentation of QRS. Five raters for each ECG lead have been used to mark the presence of fQRS. This method in comparison to other existing methods provided better results [5].

(d) For Detection of Intruder in a Network

Many algorithms and models have been used in [4] to detect the intruder in the traffic of a network. Support Vector Machine (SVM) was used to compute the intruder and its result were compared with results of Artificial
Neural Networks (ANN). It was concluded in [4] that ANN performance was better for classifying the traffic of a network. In [4], the machine learning was implemented using ANN with wrapper feature selection scheme.

3. Conclusion

The existing machine learning techniques that have been proposed or used for signal processing by different researchers are reviewed and illustrated in this work. It is observed that machine learning techniques have been used for the designing of the antenna and processing of signals generated by Radar, for the recognition of the dynamic gestures, for the processing of biomedical signals and for the detection of the intruder in a network. It is concluded that the existing machine learning algorithms can be used along with signal processing techniques for different applications.

References


