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Classification of EEG-Based Auditory Evoked Potentials Using Entropy-Based Features and Machine Learning Techniques

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***Abstract*—Hearing loss is a prevalent impairment that disrupts interactions with others and individuals' learning abilities. Immediate and accurate diagnosis of hearing loss using Electroencephalogram (EEG) signals, particularly Auditory Evoked Potentials (AEP), is considered the most effective approach to address this issue. The AEP signals, generated in the cerebral cortex in response to auditory stimuli, serve as the most reliable method for diagnosing deafness. This study introduces a novel approach for detecting hearing ability through the classification of EEG-AEP signals. The current experiment makes use of a publicly available dataset that contains AEP responses from 16 people who responded to auditory stimuli on either the left or right side. Sample Entropy is employed to extract the feature, capturing the complex temporal dynamics of the EEG signals. Four popular machine learning-based classifiers, namely Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Random Forest (RF), and Logistic Regression (LR), are utilized for classification purposes. The results indicate that SVM achieves the highest classification accuracy of 99.37% with subject-4 and the average accuracy of 90.74% is achieved with all subjects. This finding shows the effectiveness of Sample Entropy as a feature extraction technique for characterizing AEPs and highlights the potential of SVM as a robust classifier for the accurate identification of auditory stimuli localization. The accuracy achieved in this study indicates a promising direction for the development of reliable and non-invasive methods for hearing-related diagnoses.**

***Keywords*—EEG, Auditory Evoked Potential, Hearing Loss, Machine Learning, Entropy, SVM**

I. Introduction

Hearing disorders encompass various conditions that impact the regular operation of the auditory system, resulting in challenges in understanding and processing auditory stimuli. These disorders can result from various factors, including genetic predisposition, exposure to loud noises, aging, and certain medical conditions. The global population currently includes over 1.5 billion individuals, constituting nearly 20%, who are living with hearing impairment. By 2050, it is estimated that disabling hearing loss will affect more than 700 million people, equivalent to one in every ten individuals [1]. Conventional testing techniques, which rely on subjective responses, can be influenced by factors such as attention and motivation. Furthermore, its reliance on specialized equipment and trained professionals limits its accessibility [2], [3]. Besides, its primary focus on measuring hearing thresholds may overlook complex auditory processing abilities, such as speech perception in noise and temporal processing skills [4]. To address these concerns, researchers have devised various testing techniques for the detection of hearing disorders. Among these methods, the EEG-AEPs based hearing disorders diagnosis system has become the most prevalent [5].

Tang & Lee et al. [6], proposed a system involving three-class classification problems and employing wavelet entropy and Multi-Layer Perceptron (MLP). However, this method achieved a maximum accuracy of 86.17%, which is not enough for real-world applications. In [7], authors extracted Global and nodal graph-based features from EEG of normal and abnormal hearing individuals and then extracted features are classified using SVM with the maximum accuracy of 85.71% and 71.42% for classifying clear and degraded speech, respectively. In study [8], authors studied the EEG-based BCI technology for detecting AEPs in people who have communication difficulties. The proposed method successfully detected AEP responses to three English words by extracting features like FFT, PSD, and statistical measurements. Here, the SVM scored the highest overall classification accuracy of 82.86%. Zhang and colleagues [9] propose a method that combines wavelet transform and Bayesian models for the classification of auditory brainstem responses. Their approach