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Comparative Analysis of Machine Learning Classifiers for EEG Signal Classification Using LR, NLR, GMM, K-NN, and SVM

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ABSTRACT

Electroencephalography (EEG) is a widely used non-invasive technique for recording the electrical activity of the brain and is extensively applied in the diagnosis and monitoring of neurological disorders, particularly epilepsy. The accurate classification of EEG signals is essential for the early detection of epileptic seizures and for assisting neurologists in making reliable clinical decisions. However, EEG signals are highly nonlinear, non-stationary, and often contaminated with noise, making manual analysis difficult and time-consuming. This study presents a comparative analysis of machine learning classifiers for EEG signal classification using Logistic Regression (LR), Nonlinear Regression (NLR), Gaussian Mixture Model (GMM), K-Nearest Neighbors (K-NN), and Support Vector Machine (SVM) with Linear, Polynomial, and Radial Basis Function (RBF) kernels. Initially, EEG signals are preprocessed to remove artifacts and improve signal quality. Feature extraction is then performed using the Discrete Wavelet Transform (DWT) with Haar, Daubechies-4 (db4), and Symlet-8 (Sym8) wavelets to obtain meaningful time-frequency characteristics of the EEG signals. Statistical features extracted from the wavelet coefficients are used as input to the machine learning classifiers. The performance of each classifier is evaluated using standard metrics such as accuracy, sensitivity, specificity, precision, F1-score, and computational efficiency to determine the most effective approach for epileptic EEG signal classification. The comparative analysis aims to identify the classifier that provides the highest classification accuracy and robustness while maintaining computational efficiency. The findings of this study are expected to demonstrate the effectiveness of combining wavelet-based feature extraction with machine learning techniques for automated EEG signal analysis and epileptic seizure detection. The proposed framework contributes to the development of reliable computer-aided diagnostic systems that can support clinicians in improving diagnostic accuracy, reducing analysis time, and enabling early detection of epilepsy, thereby enhancing patient care and advancing intelligent healthcare applications.

Keywords: *Electroencephalography (EEG), Machine Learning Classifiers, Support Vector Machine (SVM), K-Nearest Neighbors (K-NN), Epileptic Seizure Classification.*