Abstract

The field of illness diagnosis, characterization, and classification using signal processing and feature extraction approaches has seen tremendous growth in recent years. This is a result of the global increase in the number of diseases. Among those globally, cardiovascular diseases (CVDs) are the most prevalent non-communicable health issues and one of the fundamental causes of death The dysfunction of the heart is the main cause of CVD, a condition with several symptoms. So, attention towards CVD is the root cause in the healthcare domain. The unavailability of enough health care systems and the work stress and casual lifestyle hinder routine health check-ups and precise diagnoses. A key issue has been the requirement for a prompt, affordable, and precise diagnosis, treatment, and cure at the early stage at a fair price to enhance human health. In the evolving landscape of telemedicine, the management of CVD patient data, particularly electrocardiogram (ECG) and photoplethysmogram (PPG) signals, requires efficient compression, prediction, and classification techniques. This study delves into advanced methodologies to address these challenges, ensuring optimized storage, transmission, and diagnostic capabilities for remote healthcare applications. The compression of PPG signals is critical for Internet of Things (IoT) applications, facilitating real-time monitoring through wearable devices. Efficient compression algorithms are developed to meet the demands of low-power devices, ensuring that essential diagnostic data is preserved. Fourier and Gaussian model-based compression techniques are also explored to optimize PPG data handling, with secure sharing implemented through cloud-based platforms like Dropbox. Furthermore, an integrated algorithm is proposed to compress both ECG and PPG signals effectively, ensuring compatibility with telemedicine frameworks while maintaining high diagnostic accuracy. Predicting fiducial parameters from ECG and PPG signals is essential for identifying critical markers of CVD. Neural network models, including Radial Basis Neural Networks (RBNN) and General Regression Neural Networks (GRNN), are employed to predict PPG fiducial parameters with high accuracy. Gaussian Process Regression (GPR) is introduced as a robust statistical method to accommodate inter-patient variability in physiological signals. Additionally, methods for extracting ECG fiducial parameters from PPG signals are developed, reducing the reliance on multiple monitoring devices and enhancing system scalability. Comprehensive results and analyses validate the effectiveness of these predictive techniques, demonstrating improved accuracy and reliability in clinical settings. Classification and authentication of CVD types form a cornerstone of this study. Machine learning techniques are applied to detect CVD, leveraging data-driven insights for precise identification. A one-dimensional Convolution Neural Network (1-D CNN) is designed to enhance detection accuracy by capturing temporal and spatial signal features. Composite feature engineering combines insights from both ECG and PPG signals, further improving detection performance. An algorithm is proposed for classifying unknown CVD types using the approaches of 1-D CNN and machine learning methods, ensuring adaptability to diverse clinical scenarios. The results demonstrate the superiority of these classification methods, showcasing their potential for early and accurate disease detection. This comprehensive study integrates state-of-the-art compression algorithms, predictive modeling, and classification frameworks to advance telemedicine for CVD management. By combining techniques such as Fourier and Gaussian models, RBNN, GRNN, GPR, and 1-D CNN, the proposed methodologies achieve significant improvements in data efficiency, prediction accuracy, and disease classification. The findings underscore the potential of these approaches to enhance the scalability, reliability, and accessibility of telemedicine solutions, paving the way for more effective healthcare services for CVD patients. The presented methods highlight the interplay between signal processing, machine learning, and IoT technologies, offering a robust foundation for future innovations in remote healthcare systems.

In a nutshell, the goal of this thesis is to build and develop methods for CVD detection, compression, characterization, and classification using signal processing, neural networks, machine learning, and deep learning. The development of more intricate structures to capture a variety of morphological patterns that can surpass the performance of current state-of-the-art frameworks has led to the invention and development of several machine learning and, more recently, deep learning frameworks.