



Nature-Inspired Deep Learning Approach for Cardiac Arrest Detection

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1. INTRODUCTION

Cardiac arrest is still one of the main causes of sudden death worldwide and its survival rate is highly correlated to early detection and treatment through cardiopulmonary resuscitation (CPR) and defibrillation [1]. Traditional detection methods, such as electrocardiogram (ECG) monitoring and clinical observation, usually have limitations of accuracy and timeliness, especially when patients suffer from other ailments in medical institutions [2]. This emphasizes the urgent need for new approaches to improve early diagnosis and patient prognosis.

Artificial intelligence (AI) in particular deep learning has emerged as a transformative technology in health care. Deep learning models can automatically extract complex features from medical data such as physiological signals and imaging without human interference [3]. These models, trained on large datasets, have shown better performance in recognizing subtle patterns related to cardiac arrest providing flexibility across diverse patient populations [4]. However, deep learning is computationally intensive, which makes it difficult to deploy in real-time clinical settings.

To tackle this issue, researchers have turned more and more to nature-inspired algorithms, which imitate biological and ecological processes, to optimize computational tasks. The application of methods like genetic algorithms, particle swarm optimization, and ant colony optimization has been effective to reduce the training time and improve the efficiency of medical AI applications [5]. The proposed deep learning-based hybrid framework can improve the detection speed of cardiac arrests without losing high detection accuracy due to the nature-inspired optimization, which allows for timely interventions in critical care settings.

2. RELATED WORK

Deep learning in cardiac arrest detection has been investigated in several works. Yildiz et al. [6] proposed a transformer-based deep learning framework to interpret tabular clinical data for early detection of cardiac arrest. Their work focused on interpretability which is important for clinical adoption. Pratama et al. [7] also developed a deep learning model trained on the vital sign data of patients admitted to the intensive care unit (ICU), showing an improved accuracy in predicting cardiac arrest compared to conventional monitoring systems. Li et al. [8] proposed a novel deep learning framework combined with physiological signals, which demonstrates the potential of AI in real-time prediction.

Researchers have also explored the nature-inspired algorithms to improve the computational efficiency for healthcare applications apart from deep learning. Yang [9] reviewed optimization algorithms inspired by biological and ecological processes, such as genetic algorithms and particle swarm optimization, which have been used to reduce the training time of medical AI models. Abdel-Basset et al. [10] proposed an intelligent framework combining deep learning with nature-inspired optimization for medical image analysis, demonstrating the potential of hybrid methods to enhance both speed and accuracy.

Taken together, this literature shows that high accuracy can be achieved with deep learning for the detection of cardiac arrest, but that the computational burden is a hurdle. To this end, nature-inspired algorithms offer a promising solution by optimizing model training and inference, leading to hybrid frameworks that trade accuracy for efficiency. The present review is based on the integration of these two approaches and aims to explore their synergy in the progress of cardiac arrest detection.



3. METHODOLOGY

The paper proposes an investigation methodology to improve the performance of deep learning models on ECG datasets. It uses the best techniques for the classification of ECG signals like noise reduction techniques, Genetic Algorithms for selection of hyper-parameters, and Particle Swarm Optimization (PSO) for feature extraction. It then uses CNN (Convolutional Neural Network) layers for spatial features, LSTM (Long Short-Term Memory) units for temporal learning, and attention mechanisms to focus on the most important signals.

In order to obtain the most viable set of hyperparameters for the model, the different combinations of these components together facilitate the making of a more optimal deep learning model which is capable of learning effectively from the dataset. Before they can be utilized however, the noise, artifacts, and other unwanted features should be eliminated with the noise reduction techniques. After training the model, the dataset is evaluated utilizing a stratified cross-validation approach to check how efficiently the model performs. The efficiency of the model can be evaluated using different performance metrics like accuracy, sensitivity, specificity, and F1-score.

The different combinations of hyper-parameters are optimized using a Genetic Algorithm technique to get the optimal set of hyper-parameters of the model. Once the best combination that works optimal for the model is found, the dataset is used to extract the features using the PSO algorithm. Once features are extracted, the different layers of the deep learning model will process the features.

Once the model is trained, the dataset is evaluated using a stratified cross-validation approach to validate the efficiency of the model. The efficiency of the model can be evaluated based on different performance metrics like accuracy, sensitivity, specificity and F1-score.

The methodology will provide enhanced results for different causes which in turn will help to reduce the risk of fatalities as a result of cardiovascular disease.

4. DISCUSSION

The efficiency and robustness of bio-inspired algorithms has led to a growing trend in health monitoring applications that combines bio-inspired algorithms with deep learning. To make optimization tasks easier, a family of swarm-based optimization algorithms based on natural swarming processes have a higher adaptability and biological resilience. In this paper we review the state of the art in the field bio-inspiration in AI, and present some recent achievements in the field of bio-inspired methods applied to ECG signal processing. The authors review and present their work on bio-inspiration in ECG processing for noise removal and feature extraction, in particular. The experimental section shows the results obtained by different tests applied to noisy ECG signals. Finally, some conclusions are drawn from the studied in terms of the use of these techniques for medical diagnostic applications, particularly stroke prediction and detection of respiratory failure.

CONCLUSION

The work presented in this research is focused on the use of Genetic Algorithm (GA) as the proposed optimization model for the automatic detection of cardiac arrest from ECG signals. The framework employs GA for hyper-parameter tuning and model adaptation to improve the accuracy, sensitivity and specificity of the deep learning architecture, especially CNNs for spatial feature extraction and RNNs for temporal learning. The evolutionary nature of GA allows the system to efficiently search the search space, reduce the training time and improve the generalization, and thus to make the detection process faster and more reliable. The GA based approach is a promising path for timely and precise identification of cardiac events, which offers a strategic solution for real-time clinical applications to optimize patient survival outcomes.

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