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Analysis of ECG Arrhythmia for Heart Disease Using SVM and Island-based Cuckoo Search with Highly Disruptive Polynomial Mutation (iCSPM)

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Abstract

Electrocardiogram arrhythmias are abnormal heart rhythms that can lead to serious medical conditions if undetected. Early and accurate detection of arrhythmia will play an important role in patient care. In this paper, we proposed a more optimized approach for detecting and analyzing arrhythmia using the MIT database. The classification is done for the Detection of abnormal heart rhythms using a Support vector machine (SVM) and Island-based Cuckoo Search with a highly disruptive polynomial mutation (iCSPM) Optimized Neural network.

Keywords: Island-based Cuckoo Search; support vector machine; Neural Networks; Machine Learning; Electrocardiograms; QRS; Cardiovascular disease;

I. INTRODUCTION

Cardiovascular disease (CVD) is a major public health concern, particularly in India, where it ranks as a leading cause of mortality. Heart attacks and strokes, responsible for over 80% of cardiovascular deaths, are linked to risk factors such as tobacco use, sedentary lifestyles, obesity, high blood pressure, diabetes, and genetic predispositions.

The heart, central to the cardiovascular system, is susceptible to various diseases, from benign conditions like tachycardias to life-threatening ones like myocardial infarctions. Early detection of cardiac arrhythmias is essential, as minor arrhythmias can indicate potential progression to severe forms of the condition.

Electro Cardio Grams (ECGs) are invaluable for this purpose, offering a quick, cost-effective, and non-invasive means of assessing cardiac health. ECGs represent the heart's electrical activity as waveforms, with deviations indicating cardiac dysfunctions or arrhythmias.

Recognizing arrhythmias involves preprocessing noisy Holter recordings, extracting relevant features, and using classifiers. The effectiveness of this process hinges on meticulous data preparation, feature extraction, and classification—a multidisciplinary endeavor aimed at improving cardiac healthcare.

II. LITERATURE REVIEW

Numerous studies have been conducted in medical centers, focusing on disease prediction systems utilizing various machine learning algorithms and ECG.

Dr. Dinesh D Patil, R. P. Singh, Vilas M. Thakare et al,[1] proposed an Analysis of ECG Arrhythmia for Heart Disease Detection using SVM and Cuckoo Search Optimized Neural Network, in this paper he used a Support Vector Machine and Cuckoo Search optimized neural network algorithm to detect heart disease using MIT-BIH arrhythmia database and achieved an accuracy of 99.46% for SVM and 99.98% for cuckoo search optimized neural network, he mainly focused on 4 types of abnormalities in heart rhythm RBBB, APC, PVC, and LBBB.

Cuckoo Search (CS), inspired by the brood parasitic behavior of cuckoos and Levy flight behavior, has gained recognition for its efficiency in solving complex optimization problems. Abed-alumni and Alkhateeb et al,[2] (2017) introduced several variations of the CS algorithm by replacing the random-based selection method with different randomized selection schemes, demonstrating minor improvements for benchmark functions. Alkhateeb and Abed-alguni (2017) proposed hybrid variations of CS and Simulated Annealing (SA) to mitigate local optima problems, achieving more accurate results at the cost of increased computational requirements. Additionally, Abed-alguni and Alkhateeb (2018) introduced a hybrid algorithm called CSBHC, combining CS with β-hill climbing, which exhibited promising performance in terms of solving standard test functions. However, these hybrids often achieve improved performance but at the cost of increased computational complexity. Furthermore, other studies have explored the integration of CS with algorithms like harmony search and differential evolution, showing promise in enhancing optimization outcomes. Notably, these hybrids tend to be computationally intensive. In the realm of structured population strategies, the island model has been widely adopted to improve diversity in evolutionary algorithms (Lardeux and Goeffon, 2010; Al-Betar, Awadallah, Khader

and Abdalkareem, 2015; Michel and Middendorf, 1998; Romero and Cotta, 2005; Abed-alumni and Barhoush, 2018; Kushida, Hara, Takahama and Kido, 2013). This approach partitions the population into smaller, independent islands, with candidate solutions exchanged periodically. Furthermore, mutation operators play a critical role in generating new solutions and avoiding local optima. Highly Disruptive Polynomial (HDP) mutation, as highlighted by Deb and Tiwari (2008), has proven effective in exploring entire search spaces. The research in question, conducted by Bilal H. Abed-alumni, introduces a novel variant, island-based CS with polynomial mutation (iCSPM), which addresses CS's limitations. By incorporating the island model and replacing Levy flight with HDP mutation, iCSPM demonstrates superior accuracy and offers the potential for parallel processing, reducing computational time.

In their study, Marriwala and Iyer et al,[3] address the critical issue of arrhythmia detection in ElectroCardioGram (ECG) signals, a key component of modern healthcare. Arrhythmias, irregularities in heart rhythm, are vital indicators of cardiac disorders, emphasizing the significance of their early detection for patient well-being. The authors employ a sophisticated approach by utilizing ensemble machine-learning techniques to enhance the accuracy of arrhythmia detection. They build upon a growing body of research in the field, leveraging a repertoire of machine learning algorithms such as Support Vector Machines (SVM), Random Forest, and Neural Networks. These algorithms are particularly well-suited for the extraction of relevant features from ECG data and subsequent classification tasks. What sets Marriwala and Iyer's work apart is their innovative use of ensemble methods, including Bagging and Boosting, to combine predictions from multiple base classifiers. This approach aims to significantly improve the reliability and robustness of automated arrhythmia detection systems. Their research contributes to the ongoing effort to revolutionize cardiac healthcare through advanced machine-learning techniques applied to ECG analysis. By enhancing the accuracy of arrhythmia detection and providing healthcare professionals with more reliable diagnostic tools, this work holds the promise of improving patient outcomes and strengthening the field of cardiovascular medicine

Abiyev and Cosar's[5] research focuses on the critical task of arrhythmia detection within ElectroCardioGram (ECG) signals, a pivotal aspect of modern healthcare. Arrhythmias, deviations from normal heart rhythm, serve as vital indicators of potential cardiac issues, underscoring the importance of early detection. The authors employ deep learning techniques to address this challenge. In particular, their work leverages the power of neural networks, specifically deep learning models, to automatically identify arrhythmias within ECG data. The significance of this research lies in its contribution to the growing body of knowledge regarding automated ECG analysis using deep learning. Deep learning models have demonstrated their effectiveness in feature extraction and pattern recognition, making them well-suited for tasks like arrhythmia detection. Abiyev and Cosar's work aligns with the broader efforts to enhance the automation and accuracy of arrhythmia identification, which can ultimately lead to improved patient care and more efficient healthcare systems. This research, presented in Studies in Health Technology and Informatics (2019), offers valuable insights into the application of deep learning for the vital task of arrhythmia detection within ECG signals.

TABLE 1. A COMPARATIVE STUDY OF VARIOUS MACHINE LEARNING AND A.I. TECHNIQUES IN LITERATURE REVIEW

Authors	Publication Source	Year	Methodology
[1] Dinesh D. Patil, R. P. Singh, Vilas M. Thakare	International Journal of Engineering & Technology	2018	SVM and Cuckoo Search Optimized Neural Network
[2] Bilal H. Abed-alguni	ResearchGate	2019	Island-based Cuckoo Search with highly disruptive polynomial mutation (iCSPM)
[3] Marriwala, H., Iyer, R.	Procedia Computer Science	2019	Ensemble of Machine Learning Algorithms
[4] Pourmohammadi, A., Marateb, H.R., Eslahchi, C.	Journal of Medical Signals & Sensors	2020	Long Short-Term Memory (LSTM) Network
[5] Abiyev, R.H., Cosar, A.	Studies in Health Technology and Informatics	2019	Deep Learning
[6] Zhang, J., Kang, X., Liu, L., et al.	Expert Systems with Applications	2013	Feature-Based Data Mining and Fuzzy Neural Network
[7] Maheswari, S., Thanushkodi, K., Dash, S.	Biomedical Signal Processing and Control	2018	Modified Grey Wolf Optimization and Random Forest
[8] Bang, S.Y., Lee, T.H.	Expert Systems with Applications	2014	Particle Swarm Optimization
[9] Rajpurkar, F., Hannun, A.Y., Haghpanahi, M., et al.	arXiv preprint	2017	Convolutional Neural Network (CNN)

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