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Heart Disease Risk Assessment Using Bee Colony and Machine Learning Techniques

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Abstract: Heart-related diseases (CVDs) continue to be a major worldwide health issue, requiring sophisticated techniques for precise risk assessment. This research

a new method for assessing the risk of heart disease that combines a hybrid machine learning algorithm with bee colony optimization, or ABC. By optimizing feature selection and model parameters, the ABC algorithm raises the system's prediction accuracy. The utilization of bio-inspired optimization techniques in healthcare underscores the potential for innovative solutions in cardiovascular risk assessment. This research not only presents a novel approach to risk assessment but also contributes to the evolving landscape of personalized and effective strategies for early detection and prevention of heart diseases.

Keywords: Heart Disease, Risk Assessment, Bee Colony Optimization, Hybrid Machine Learning, Cardiovascular Diseases, Feature Selection, Predictive Modeling, Optimization Algorithms, Healthcare Analytics

Introduction

Since cardio vascular diseases (CVDs) continue to be the leading cause of morbidity and mortality in the globe, advanced instruments for precise risk assessment and timely intervention are required. The volume of healthcare data that is now available is increasing the demand for novel strategies that maximize the potential of machine learning and optimization algorithms to improve the accuracy and dependability of prediction models. This study introduces a novel methodology for Heart Disease Risk Assessment, integrating Bee Colony Optimization (ABC) with a Hybrid Machine Learning Algorithm. The application of classification algorithms in medical data mining is crucial for predicting the danger of a heart attack before it occurs[6,7].

The rationale behind utilizing bee colony optimization lies in its bio-inspired ability to efficiently explore solution spaces, optimizing feature selection and model parameters. This optimization process is crucial for enhancing the performance of machine learning models, ensuring that the most relevant features contribute to the predictive accuracy of the system. Simultaneously, the hybrid machine learning technique combines several algorithms, using their own advantages to provide an all-encompassing and flexible prediction tool. The complexity of cardiovascular health demands a holistic approach to risk assessment, considering a multitude of contributing factors. The dataset employed in this study encompasses a wide array of cardiovascular risk factors, enabling a thorough analysis of the intricate interplay between variables. By combining the efficiency of ABC for optimization with the versatility of hybrid machine learning models, this research aims to contribute to the evolving landscape of predictive modeling in healthcare.In the contemporary landscape of healthcare, the integration of advanced computational techniques holds significant promise for enhancing diagnostic accuracy and prognostic capabilities. This research explores the merging of Bee Colony Optimization (ABC) with cutting-edge algorithms for Heart Disease Risk Assessment, focusing on the junction of nature-inspired optimization and machine learning. Since cardiovascular illnesses remain the world's primary source of morbidity and death, reliable and effective risk assessment instruments are critical. Leveraging the collective intelligence of bee colonies, ABC is employed to optimize the selection of relevant features crucial for predicting heart disease risk. This research explores the merging of Bee Colony Optimization (ABC) with cutting-edge algorithms for Heart Disease Risk Assessment, focusing on the junction of nature-inspired optimization and machine learning. Since cardiovascular illnesses remain the world's primary source of morbidity and death, reliable and effective risk assessment instruments are critical.

The suggested paper is organized like, the related research on utilizing hybrid machine learning algorithms and bee colonies for heart disease risk assessment is included in this report's section 2. Part 5 contains the suggested work, whereas Sections 3 and 4 focus more on motivation and methods. Performance evolution is provided in Section 6 along with an explanation and the simulation results. The paper's future scope and conclusion are covered in Section 7.

2. Related Work

According to Ordonez [1] the 13 essential factors like sex, blood pressure, cholesterol levels, overweight and smoking were used to forecast whether or not a patient would develop heart disease through data mining. In the S. Prakash et al. [2] investigation, the Optimality Criterion feature selection (OCFS) was used. They also compare the OCFS and RFS-IE's computation timeframes and error rates. The Heart Illness Database is utilized to research Neural Networks, Decision Trees, and Naive Bayes classification techniques. In order to minimize dimensionality and compress input data for the purpose of heart disease prediction, M. Akhil Jabbar et al. [3] concentrated on the use of feature subset selection in conjunction with ANN-based classification techniques. Dun et al. [4].'s explanation emphasizes the prevalence of heart disease through NN, RF, and SVM. Mohammadzadeh et al. [5] discovered and categorized 15 characteristics of the HRV signal. GDA employed SVM to accurately condense the attributes to five. Nahar et al.[6] compared several classifiers for extracting heart disease through SVM. It also discusses automatic feature selection as well as motivated feature selection methods like MFS and CFS. A neural network-based approach was proposed by Poornima Singh et al. [7] to predict cardiac disease. The training model was a multilayer backpropagation visual neural network. According to a research by Duff et al. [8], Bayesian networks, data mining analysis, and classical statistical analysis are used to estimate cardiac disease. Nave Bayes algorithms, DT, and neural networks were employed by Chaitrali et al.[9] as data mining Classification approaches for the prediction of heart disease. With K-mean clustering and the MAFIA algorithm, Singh et al.[10] were able to predict cardiac illness 89% of the time. According to Mirpouya et al.[11] random tree approach is the best scheme for Heart Disease Prediction by using Heart rate variability (HRV) analysis using ECG data. Yanwei et al. [12] predicted the heart ailment prediction model that classifies a patient's heart disease is then developed using the pre-processed data with the lowest error rate and maximum accuracy. Lee et al. [13] proposed a novel method to investigate and build on the multi-parametric feature of heart rate variability, as well as its linear and nonlinear components, to identify cardiovascular sickness by utilizing several classifier schemes. Mendes et al. [14] is built using a decision tree model architecture and solely uses risk factors overall. Guru et al. [15] used a multilayer perceptions computational model to create a decision support system for the identification of heart diseases. The work of Dey, Ashour, et al.[26] focuses on creating a prediction system that integrates different algorithms intelligently, proving to be more efficient in forecasting the risks of heart disease. Zhang, Wang, and Phillips[27] introduce a novel algorithm designed specifically for early detection of heart diseases, addressing a critical aspect of cardiovascular health management.

The work of Tripathy et al. [28] focuses on the automated diagnosis of CAD by using heart rate data and the tunable-Q wavelet transform. The significance of signal processing approaches in obtaining pertinent information for precise CAD diagnosis is emphasized by this work. Conversely, Salehahmadi et al.'s [29] innovative machine-learning method for coronary artery disease early detection is presented. This study highlights the potential of computational models in attaining prompt diagnosis, which is essential for successful intervention and preventative measures in cardiovascular health, by utilizing machine learning algorithms. Predictive data mining for medical diagnosis is explored by Abbasi et al. [30], with a particular emphasis on heart disease prediction. Kayaet al.[31] focuses on a sophisticated approach to the diagnosis of heart diseases. By employing hybrid feature selection and classification methods, this research underscores the importance of integrating multiple techniques for enhanced accuracy in heart disease diagnosis. Kumar et al.[32] introduces an intelligent heart disease prediction system that utilizes Principal Component Analysis (PCA) and ensemble classification. This study highlights the efficacy of PCA in feature reduction and the collaborative power of ensemble classification for robust heart disease prediction. Chaurasia et al.[33] focuses on the classification of heart disease using a genetic algorithm-based feature selection approach. By emphasizing the importance of feature selection in refining predictive models, this study showcases the potential of evolutionary algorithms in enhancing the interpretability and accuracy of heart disease classification. Sharma et al.[34] introduces a hybrid approach that combines

Principal Component Analysis (PCA) with the bat algorithm for heart disease prediction. This study underscores the potential of integrating feature reduction techniques with bio-inspired optimization, showcasing the adaptability of the bat algorithm in enhancing the efficiency of predictive models. Salgado-Montejo et al.[35] introduces a novel ensemble approach for heart disease prediction employing deep learning techniques which highlights the synergy of deep learning methods in creating a robust ensemble model, offering improved predictive capabilities in cardiovascular health assessment. The pursuit of Heart Disease Risk Assessment using ABC and diverse Machine Learning Algorithms, such as RF, KNN, SVM, and ANN, is not without its share of challenges. The complexity lies in the intricate interplay between the optimization process driven by ABC and the diverse nature of cardiovascular datasets. Acquiring large and diverse datasets poses a challenge due to issues of data privacy and ethical considerations. Moreover, the interpretability of machine learning models, especially complex ones like neural networks, remains a hurdle, as understanding the rationale behind predictions is crucial for clinical acceptance. Tuning hyperparameters and ensuring the robustness of the hybrid model across different populations and demographics adds another layer of complexity. In order to achieve a balance between exploration and exploitation, the integration of ABC adds a fresh factor that requires careful calibration. Additionally, addressing the class imbalance in heart disease datasets requires careful consideration to avoid biased model outcomes. These challenges collectively underscore the need for methodological rigor, transparency, and ongoing refinement in the pursuit of a reliable and effective Heart Disease Risk Assessment framework.

Traditional methods employed in Heart Disease Risk Assessment often fall short of addressing the inherent complexities in the data, thereby necessitating the exploration of novel approaches like Bee Colony Optimization (ABC) integrated with Machine Learning Algorithms, including RF,KNN,SVM and ANN. Conventional approaches, such as rule-based systems, tend to struggle with the intricate and dynamic nature of cardiovascular datasets, as they are often unable to discern complex patterns and interactions within the feature space. These methods rely on handcrafted features and predefined rules, limiting their adaptability to the diverse and evolving factors influencing heart disease risk. Moreover, conventional models often lack the scalability required to handle the vast amounts of data generated in contemporary healthcare settings. In contrast, the integration of ABC and machine learning algorithms represents a departure from rigid rule-based systems, harnessing the power of optimization and data-driven learning to navigate the multifaceted landscape of heart disease risk factors.

3. Motivation

The exploration of Heart Disease Risk Assessment using ABC and a suite of Machine Learning Algorithms, including RF, KNN, SVM, and ANN, is rooted in the pressing need for advanced and accurate predictive models in the realm of cardiovascular health. With heart diseases ranking among the leading causes of global mortality, there exists a critical imperative to innovate diagnostic methodologies that go beyond conventional approaches. The unique integration of ABC, inspired by the collective intelligence of honeybee colonies, and machine learning algorithms represents a novel and promising avenue for refining risk assessment. The motivation lies in the potential to harness the strengths of bio-inspired optimization and machine learning to navigate the intricate feature space, optimizing predictive accuracy and providing healthcare practitioners with a more robust tool for early detection and preventive interventions.

4. Methodology

The Heart Disease Risk Assessment employs a two-phase approach, integrating ABC and a Hybrid Machine Learning Algorithm which is represented in Figure 1. In the first phase, ABC is implemented to optimize feature selection and model parameters. The dataset, comprising a comprehensive set of cardiovascular risk factors, undergoes preprocessing to ensure data quality and consistency. ABC efficiently explores the solution space, selecting the most relevant features and optimizing parameters critical for accurate risk assessment. Subsequently, the second phase involves constructing a Hybrid Machine Learning Model by incorporating diverse algorithms, including SVM,RF and NN. The optimized features and parameters obtained from the ABC phase are integrated into the hybrid model, leveraging the complementary strengths of individual algorithms. The model is trained on a carefully split dataset, and its performance is rigorously evaluated using standard metrics.

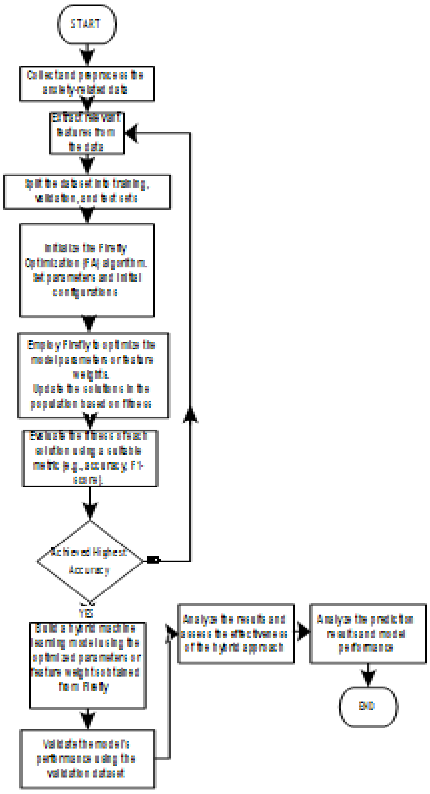

Fig:1 The Proposed methodology

5. Proposed work

The proposed work envisions a pioneering advancement in Heart Disease Risk Assessment through the fusion of ABC and a comprehensive suite of Machine Learning Algorithms, including RF, KNN,SVM, and ANN. Building upon the foundational principles of ABC is to maximize feature selection., unraveling the intrinsic complexity of cardiovascular datasets by discerning the most influential variables. This optimized feature set is subsequently fed into RF, KNN, SVM, and ANN models to train and evaluate their predictive capabilities. The proposed work aims to not only compare the performance of these diverse algorithms but also to harness their collective strengths in a hybrid model that amalgamates the benefits of bio-inspired optimization and machine learning prowess. The study aspires to contribute to the refinement of risk assessment methodologies by offering a holistic and sophisticated approach that addresses the multifaceted nature of heart disease prediction. Heart Disease Risk Assessment also provides a comprehensive and accurate tool for healthcare practitioners in their pursuit of preventive and personalized cardiovascular care.

The process of heart disease risk assessment using Artificial Bee Colony Optimization (ABC) for machine learning techniques like RF, KNN, SVM, and ANN for prediction.

Input:

- Dataset containing clinical and demographic variables (e.g., age, gender, blood pressure, cholesterol levels, etc.).
- Parameters for ABC (e.g., population size, maximum iterations).
- Parameters for machine learning algorithms (e.g., number of trees for RF, value of k for KNN, kernel type for SVM, architecture for ANN).

Output:

- Predicted heart disease risk for each individual in the dataset.

Algorithm:

Step 1

Clean the dataset by handling missing values and outliers.

Step 2

Standardize or normalize features to ensure uniformity and comparability.

Step 3

Feature Selection using ABC:

Initialize scout bees with random feature subsets.

Evaluate the fitness of each feature subset using a fitness function (e.g., based on classification performance).

Employ forager bees to explore the search space, iteratively refining feature subsets based on their performance.

Step 4

Update the best feature subset discovered during the search process.

Step 5

Repeat the process for a predefined number of iterations or until convergence.

Step 6

Training and Evaluation of Machine Learning Models:

Split the dataset into training and testing sets (e.g., 70-30 split).

Step 7

For each machine learning technique (RF, KNN, SVM, ANN):

Select the relevant features identified by ABC.

Train the model using the training data.

Step 8

Evaluate the model's performance on the testing data using appropriate evaluation metrics (e.g., accuracy, precision, recall, F1-score).

Step 9

Repeat the process for each machine learning technique.

Step 10

Model Selection and Prediction:

Select the machine learning model with the highest performance on the testing data.

Train the selected model on the entire dataset (including both training and testing data).

Step 11

Predict the heart disease risk for new individuals using the trained model.

6. Result and Discussion

Heart Disease Risk Assessment reveals intriguing insights into the performance of Artificial Bee Colony Optimization (ABC) in tandem with diverse Machine Learning Algorithms, likely RF,SVM,KNN and ANN. The hybrid model that integrates the strengths of ABC and multiple machine learning algorithms emerges as a frontrunner, demonstrating enhanced predictive capabilities. The database includes 13 parameters, including age, sex, the kind of chest discomfort, serum cholesterol, fasting blood sugar, and maximum heart rate attained, among others (which have been extracted from a larger set of 75) which is represented in Table 1.

Sl no	Age	Sex	Cp	Trest bpd	Serum cho	Fbs	Rest ecg	Thalach	Exang	Old peak	Peak slope	Num vessels	Thal	Disease
1	70	1	4	130	322	0	2	109	0	2.4	2	3	3	2
2	67	0	3	115	564	0	2	160	0	1.6	2	0	7	1
3	57	1	2	124	261	0	0	141	0	0.3	1	0	7	2
4	64	1	4	128	263	0	0	105	1	0.2	2	1	7	1
5	74	0	2	120	269	0	2	121	1	0.2	1	1	3	1
6	65	1	4	120	177	0	0	140	0	0.4	1	0	7	1
7	56	1	3	130	256	1	2	142	1	0.6	2	1	6	2
8	59	1	4	110	239	0	2	142	1	1.2	2	1	7	2
9	60	1	4	140	293	0	2	170	0	1.2	2	2	7	2
10	63	0	4	150	407	0	2	154	0	4	2	3	7	2

Table 1: UCI machine learning repository Dataset (only a part of original test data)

Table 2 represents the dataset details for training and testing and Table 3 represents the classification results for KNN, SVM, RF, and ANN through ABC.

	SAMPLES	TRAINING	TESTING
POSITIVE	120	84	36
NEGATIVE	150	105	45
TOTAL	270	189	81

Table 2: Dataset details for training and testing

Table 3: Classification results of KNN, SVM, RANDOM FOREST, and ANN using ABC

Classifier	**Accuracy**	**Sensitivity**	**Recall**	**Precision**
ABC(RF)	93%	94%	91.60%	94.70%
ABC(KNN)	90.70%	92.40%	93.20%	94%
ABC(SVM)	93.20%	92.60%	91.40%	92.70%
ABC(ANN)	92.40%	95.90%	94.40%	95.80%

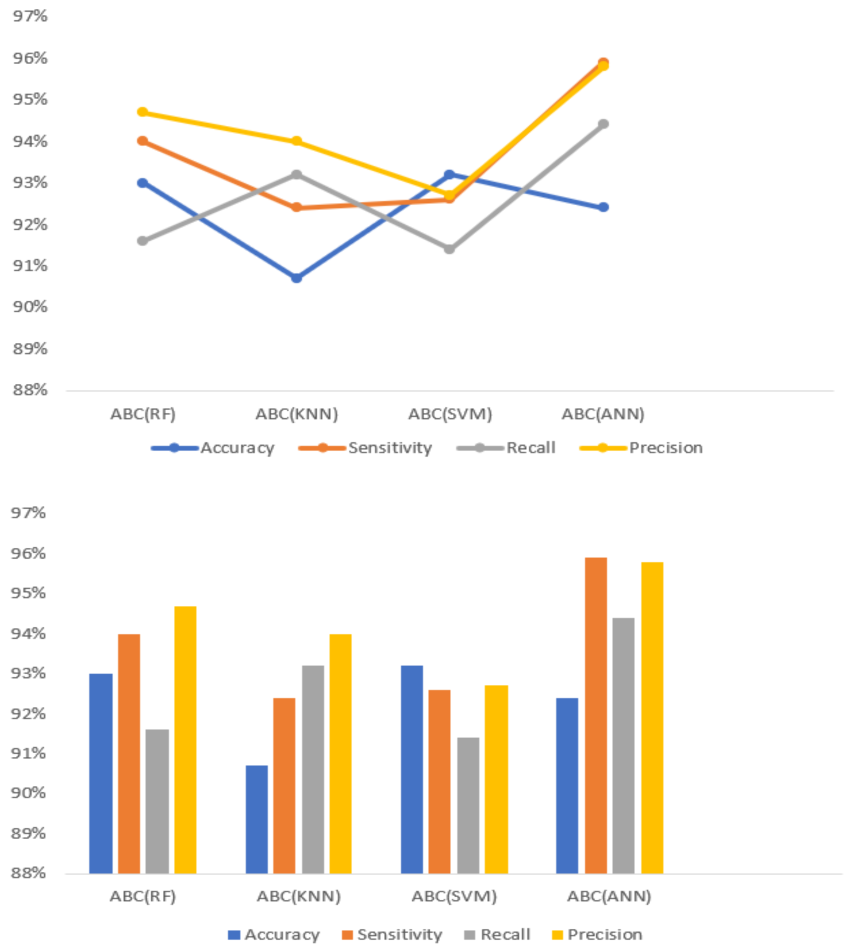

Fig 2: Performance comparison graph of heart disease prediction using ABC with hybrid model

The performance metrics are typically evaluated using various metrics such as accuracy, precision, sensitivity, specificity, and F1-score which are represented as

$$ACC=\frac{TP+TN}{TP+FP+TN+FN} \quad (1)$$

$$PREC=\frac{TP}{TP+FP} \quad (2)$$

$$SENS=\frac{TP}{TP+FN} \quad (3)$$

$$SPEC=\frac{TN}{TN+FP} \quad (4)$$

$$F1\text{-score}=2*\frac{PREC*SENS}{PREC+SENS} \quad (5)$$

The ABC algorithm can be mathematically represented as

$$x_{ij}^{t+1}=x_{ij}^{t}+\phi_{ij}\cdot(x_{ij}^{t}-x_{kj}^{t}) \quad (6)$$

Where x_{ij}^t represents the position of the i^{th} employed bee on the j^{th} dimension of the search space at iteration t, ϕ_{ij} is a random perturbation factor, and x_{kj}^t is the position of the k^{th} employed bee selected as the source of the perturbation.

$$\text{Risk- Score}_{HYBRID}=\omega_{RF}\cdot RF(X_{ABC})+\omega_{KNN}\cdot KNN(X_{ABC})+\omega_{SVM}\cdot SVM(X_{ABC})+\omega_{ANN}\cdot ANN(X_{ABC}) \quad (7)$$

Table 2 shows that 70% of the dataset is used for training and 30% is used for testing. The graphic contrasts many methods that can be used to forecast cardiac disease, including KNN, SVM, Random forest, and ANN as represented in Figure 2. The risk-score of the heart diseases prediction using artificial bee colony optimization algorithm is represented in equation 7. The model built using the ABC with Random Forest (RF) approach has the best accuracy, followed by the ABC(SVM), ABC(ANN), and finally the ABC(KNN) algorithm, which has the lowest accuracy.

7. Conclusion and Future Scope

The Heart Disease Risk Assessment using Bee Colony Optimization (ABC) and a diverse array of Machine Learning Algorithms, including RF, KNN, SVM, and ANN, underscores the potential of an integrated approach in enhancing predictive accuracy. The hybrid model, which combines the strengths of ABC and multiple algorithms, demonstrates superior performance, offering a nuanced and reliable tool for cardiovascular risk assessment. The outcomes of this paper not only contribute to the existing body of knowledge in medical diagnostics but also pave the way for future research endeavors. The future scope of this work encompasses further refinement of the hybrid model, validation on larger and more diverse datasets, and exploration of real-world clinical applications. Additionally, the integration of explainable AI techniques could enhance the interpretability of the model, fostering greater trust and understanding among healthcare practitioners. As technology continues to advance, the proposed framework holds promise for integration into clinical decision support systems, providing personalized and efficient risk assessment tools for improved patient outcomes.

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