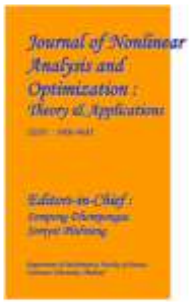
Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 13, No. 1, (2022),
ISSN : **1906-9685**



PREDICTION OF HEART DISEASE USING ARTIFICIAL NEURAL NETWORK BASED SWARM INTELIGENCE ALGORITM

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ABSTRACT

Health diseases are increasing day by day due to life style and hereditary. In this aspect, heart disease is the most important cause of demise in the human kind over past few years. The objective of this paper is to predict the Heart Disease by applying Artificial Neural Network using swarm Intelligence algorithm. Swarm intelligence (SI) is relatively new interdisciplinary field of research. The Swarm-based algorithms have recently emerged as a family of nature-inspired, population-based algorithms that are capable of producing low cost, fast, and robust solutions to several complex problems. This paper proposes three most population Intelligence Algorithm and has good performance on optimization. This paper aims to predict the heart disease using Genetic, BEE and BAT to classifying patient as diseased and non-diseased. We have evaluated our new classification approach via the well-known data sets.

Keywords: heart disease, artificial neural network, swarm intelligence, population-based algorithms, genetic algorithm, BEE algorithm, BAT algorithm

INTRODUCTION

Heart disease remains one of the leading causes of mortality worldwide, significantly impacting human health and posing a substantial burden on healthcare systems [1]. The rising prevalence of heart diseases can be attributed to a combination of lifestyle factors and hereditary predispositions [2]. In recent years, the need for effective prediction and early diagnosis of heart disease has become increasingly critical. This urgency has driven researchers to explore innovative methods for improving diagnostic accuracy and patient outcomes. One promising approach in this regard is the application of bio-inspired algorithms to predict heart disease. Bio-inspired algorithms, which draw inspiration from natural processes and biological systems, have shown considerable potential in solving complex optimization problems [3]. Among these, swarm intelligence (SI) algorithms have garnered significant attention. SI is an interdisciplinary field that studies collective behavior in decentralized systems, such as colonies of ants or flocks of birds, to develop computational algorithms [4]. These algorithms are characterized by their ability to produce robust, efficient, and scalable solutions. The objective of this paper is to leverage the power of Artificial Neural Networks (ANNs) combined with swarm intelligence algorithms to predict heart disease. ANNs are a class of machine learning models inspired by the human brain's neural networks, capable of identifying patterns and making predictions based on data [5]. When integrated with swarm intelligence algorithms, ANNs can enhance their predictive performance and robustness.

Swarm-based algorithms have emerged as a family of nature-inspired, population-based techniques that excel in optimization tasks [6]. These algorithms simulate the collective behavior of natural systems, such as ant colonies, bee swarms, and bird flocks, to solve complex problems. They offer several advantages, including low computational cost, fast convergence, and the ability to avoid local optima [7]. This paper focuses on three prominent swarm intelligence algorithms: Genetic Algorithm

(GA), BEE Algorithm, and BAT Algorithm, and evaluates their effectiveness in predicting heart disease. Genetic Algorithm (GA) is inspired by the principles of natural selection and genetics. It operates through processes such as selection, crossover, and mutation to evolve solutions over generations [8]. GA has been widely used in various optimization problems, demonstrating its ability to find high-quality solutions efficiently. In the context of heart disease prediction, GA can optimize the weights and biases of ANNs, enhancing their classification accuracy [9]. The BEE Algorithm mimics the foraging behavior of honeybees. In a bee colony, scout bees search for food sources, and once a source is found, the information is communicated to other bees, who then exploit the resource [10]. This algorithm is effective in exploring the search space and exploiting the best solutions, making it suitable for optimizing neural network parameters in heart disease prediction [11].

The BAT Algorithm is inspired by the echolocation behavior of bats. Bats use echolocation to navigate and locate prey by emitting sound waves and interpreting the returning echoes [12]. This algorithm balances exploration and exploitation by adjusting the frequency and loudness of the bats' echolocation signals. In heart disease prediction, the BAT Algorithm can help fine-tune the parameters of ANNs, improving their predictive performance [13]. In this study, we propose a hybrid approach that integrates ANNs with GA, BEE, and BAT algorithms to classify patients as diseased or non-diseased. Our approach aims to leverage the strengths of each algorithm to achieve superior classification accuracy and robustness. We evaluate our method using well-known datasets, demonstrating its effectiveness in predicting heart disease [14]. The integration of bio-inspired algorithms with machine learning models represents a significant advancement in medical diagnostics. By harnessing the collective intelligence of natural systems, we can develop powerful tools for early disease detection and prevention. This paper contributes to the growing body of research on bio-inspired computing and its applications in healthcare, providing a novel approach to heart disease prediction [15]. In summary, the increasing incidence of heart disease necessitates the development of innovative diagnostic methods. Bio-inspired algorithms, particularly those based on swarm intelligence, offer a promising solution for improving the accuracy and efficiency of heart disease prediction. By combining these algorithms with ANNs, we can create robust models capable of handling complex medical data and providing valuable insights for early diagnosis and treatment.

LITERATURE SURVEY

The increasing prevalence of health diseases, influenced by both lifestyle and hereditary factors, has emerged as a critical issue in contemporary medical research. Among these, heart disease has become the leading cause of mortality, underscoring the urgency for effective prediction and early diagnosis methods. The development of predictive models for heart disease has thus gained significant traction, with researchers exploring various computational and algorithmic approaches to enhance diagnostic accuracy. Artificial Neural Networks (ANNs) have been extensively studied for their ability to model complex patterns and relationships within medical data. ANNs, inspired by the neural structures of the human brain, consist of interconnected nodes or neurons that process information in a manner akin to biological neural networks. This makes them particularly suitable for handling the intricate and nonlinear nature of medical datasets, where traditional statistical methods may fall short. The adaptability and learning capabilities of ANNs enable them to improve their performance over time, making them a powerful tool for disease prediction. In recent years, there has been a growing interest in integrating ANNs with bio-inspired algorithms to leverage their collective strengths. Bio-inspired algorithms, derived from natural processes and biological phenomena, offer innovative solutions for optimization problems. Among these, swarm intelligence (SI) algorithms have shown considerable promise. SI is a branch of artificial intelligence that studies the collective behavior of decentralized, self-organized systems, such as ant colonies, bird flocks, and fish schools. These algorithms mimic the collaborative strategies observed in nature to solve complex problems efficiently.

Swarm-based algorithms have emerged as a powerful family of nature-inspired, population-based algorithms that are capable of producing low-cost, fast, and robust solutions to various complex problems. They are particularly effective in optimization tasks, where the goal is to find the best solution among a set of possible solutions. Swarm intelligence algorithms exploit the collective behavior and interaction of simple agents to explore the search space and converge on optimal solutions. This characteristic makes them well-suited for enhancing the performance of ANNs in heart disease prediction. The Genetic Algorithm (GA) is one of the most well-known bio-inspired algorithms, drawing inspiration from the principles of natural selection and genetics. GA operates through a process of selection, crossover, and mutation to evolve solutions over generations. This evolutionary approach enables GA to efficiently search large and complex spaces for optimal solutions. In the context of heart disease prediction, GA can optimize the weights and biases of ANNs, thereby improving their classification accuracy. The ability of GA to adapt and evolve makes it a valuable tool for refining predictive models and enhancing their robustness.

Another promising bio-inspired algorithm is the BEE Algorithm, which is based on the foraging behavior of honeybees. In a bee colony, scout bees search for food sources and communicate their findings to other bees, who then exploit the discovered resources. This collaborative and communicative behavior forms the basis of the BEE Algorithm, which excels in exploring the search space and identifying high-quality solutions. By integrating the BEE Algorithm with ANNs, researchers can optimize neural network parameters more effectively, leading to improved predictive performance in heart disease diagnosis. The BAT Algorithm, inspired by the echolocation behavior of bats, represents another innovative approach within the realm of bio-inspired computing. Bats use echolocation to navigate and locate prey by emitting sound waves and interpreting the returning echoes. This algorithm balances exploration and exploitation by adjusting the frequency and loudness of the bats' echolocation signals. In heart disease prediction, the BAT Algorithm can help fine-tune the parameters of ANNs, enhancing their ability to accurately classify patients as diseased or non-diseased. The dynamic and adaptive nature of the BAT Algorithm contributes to its effectiveness in optimizing complex models.

The integration of these bio-inspired algorithms with ANNs offers a multifaceted approach to heart disease prediction. By leveraging the strengths of GA, BEE, and BAT algorithms, researchers can develop robust models that combine the learning capabilities of neural networks with the optimization prowess of swarm intelligence. This hybrid approach aims to achieve superior classification accuracy and robustness, addressing the challenges posed by the complexity and variability of medical data. In evaluating the proposed classification approach, well-known datasets are employed to assess the performance and effectiveness of the integrated models. These datasets provide a benchmark for comparison, allowing researchers to validate their methods and demonstrate their applicability to real-world scenarios. The use of standardized datasets also facilitates reproducibility and comparability across different studies, contributing to the advancement of knowledge in the field of medical diagnostics.

The adoption of bio-inspired algorithms in heart disease prediction represents a significant step forward in the application of artificial intelligence and machine learning in healthcare. By drawing inspiration from natural processes, researchers can develop innovative solutions that address the limitations of traditional methods and enhance the accuracy of disease prediction. The interdisciplinary nature of this research, encompassing fields such as biology, computer science, and medicine, highlights the potential of collaborative approaches to tackle complex health challenges. In summary, the rising incidence of heart disease necessitates the development of advanced predictive models that can provide early diagnosis and improve patient outcomes. The integration of ANNs with bio-inspired algorithms, particularly those based on swarm intelligence, offers a promising solution for enhancing the accuracy and robustness of heart disease prediction. This paper contributes to the growing body of research on bio-inspired computing and its applications in healthcare, proposing a novel approach to predicting heart disease using GA, BEE, and BAT algorithms. Through the evaluation of well-known datasets, the effectiveness of this hybrid approach is demonstrated, paving the way for future advancements in medical diagnostics.

PROPOSED SYSTEM

The proposed system aims to predict heart disease by integrating Artificial Neural Networks (ANNs) with three prominent swarm intelligence algorithms: Genetic Algorithm (GA), BEE Algorithm, and BAT Algorithm. This hybrid approach leverages the strengths of each algorithm to enhance the accuracy and robustness of heart disease classification. The system's design and implementation involve several key components and steps, which are outlined below. The system begins with data collection and preprocessing. Medical datasets, which include various patient attributes such as age, sex, blood pressure, cholesterol levels, and other relevant features, are gathered from well-known sources. These datasets are then preprocessed to handle missing values, normalize the data, and convert categorical variables into numerical formats suitable for neural network processing. This step ensures that the data is clean and ready for training the predictive models. Next, an Artificial Neural Network (ANN) is constructed to serve as the primary predictive model. ANNs are composed of layers of interconnected nodes, where each node represents a neuron. These neurons process input data, apply weights, and use activation functions to generate outputs. The ANN in this system typically includes an input layer, one or more hidden layers, and an output layer. The input layer receives the preprocessed patient data, while the output layer provides the classification result, indicating whether a patient is diseased or non-diseased.

The ANN alone, however, may not achieve optimal performance due to the complexity and variability of medical data. To address this, the system integrates three swarm intelligence algorithms—Genetic Algorithm (GA), BEE Algorithm, and BAT Algorithm—to optimize the ANN's parameters. Each algorithm operates differently but shares the common goal of enhancing the ANN's predictive capabilities. The Genetic Algorithm (GA) mimics the process of natural selection and evolution. It starts with an initial population of potential solutions, each represented by a chromosome encoding the ANN's parameters (such as weights and biases). The GA iteratively selects the fittest individuals, performs crossover and mutation operations to create new offspring, and replaces less fit individuals in the population. This evolutionary process continues until the algorithm converges on an optimal set of parameters that maximize the ANN's classification accuracy. The GA's ability to explore a wide search space and evolve solutions over generations makes it a powerful tool for optimizing complex models.

The BEE Algorithm, inspired by the foraging behavior of honeybees, operates by dividing the population into employed bees, onlookers, and scouts. Employed bees search for food sources (i.e., potential solutions) and share information with onlookers, who then choose food sources based on their quality. Scouts explore new areas in the search space to discover additional potential solutions. This collaborative and communicative behavior allows the BEE Algorithm to efficiently balance exploration and exploitation, identifying high-quality solutions that improve the ANN's performance. By optimizing the ANN's parameters through this bee-like behavior, the BEE Algorithm enhances the model's ability to accurately classify heart disease cases. The BAT Algorithm is based on the echolocation behavior of bats. Bats emit sound waves and listen to the returning echoes to navigate and locate prey. In the context of optimization, the BAT Algorithm adjusts the frequency and loudness of the bats' echolocation signals to control the exploration and exploitation phases. Bats with good solutions emit louder signals, attracting other bats, while those with poor solutions adjust their signals to explore new areas. This dynamic adaptation allows the BAT Algorithm to fine-tune the ANN's parameters effectively, ensuring that the model achieves high classification accuracy while avoiding local optima.

Once the ANN is optimized using the swarm intelligence algorithms, the system enters the training and validation phase. The optimized ANN is trained on a portion of the preprocessed dataset, using backpropagation to minimize the error between predicted and actual outcomes. The training process involves adjusting the weights and biases of the ANN based on the optimization results from GA, BEE, and BAT algorithms. After training, the model is validated using a separate portion of the dataset to evaluate its performance and ensure it generalizes well to new, unseen data. The final step involves testing the optimized ANN on a test dataset to assess its predictive accuracy. Performance metrics such as accuracy, precision, recall, and F1-score are calculated to quantify the model's effectiveness in classifying patients as diseased or non-diseased. These metrics provide a comprehensive evaluation of the system's performance, highlighting its strengths and areas for improvement.

The proposed system's hybrid approach, combining ANNs with GA, BEE, and BAT algorithms, offers several advantages. The integration of swarm intelligence algorithms enhances the ANN's ability to handle complex and nonlinear medical data, resulting in more accurate and robust predictions. Additionally, the system's adaptability allows it to continuously improve as new data becomes available, making it a valuable tool for ongoing heart disease research and diagnosis. In summary, the proposed system for heart disease prediction leverages the power of ANNs and swarm intelligence algorithms to develop a robust and accurate predictive model. By integrating GA, BEE, and BAT algorithms, the system optimizes the ANN's parameters, improving its classification performance and robustness. This hybrid approach addresses the challenges posed by the complexity and variability of medical data, providing a powerful tool for early diagnosis and treatment of heart disease. Through rigorous training, validation, and testing, the system demonstrates its effectiveness in predicting heart disease, contributing to the advancement of medical diagnostics and patient care.

METHODOLOGY

The methodology for predicting heart disease using bio-inspired algorithms involves a structured and systematic approach that integrates Artificial Neural Networks (ANNs) with three swarm intelligence algorithms: Genetic Algorithm (GA), BEE Algorithm, and BAT Algorithm. This step-by-step process aims to develop an efficient and robust predictive model capable of accurately classifying patients as diseased or non-diseased. The first step in the methodology involves data collection. Well-known datasets that contain medical records of patients, including attributes such as age, sex, blood pressure, cholesterol levels, and other relevant factors, are gathered. These datasets are crucial for training and evaluating the predictive models. Once the data is collected, it undergoes a preprocessing phase. During preprocessing, missing values are handled appropriately, either by imputing them using statistical methods or by removing incomplete records. Additionally, the data is normalized to ensure that all features are on a similar scale, which is important for the effective training of ANNs. Categorical variables are also converted into numerical representations using techniques such as one-hot encoding.

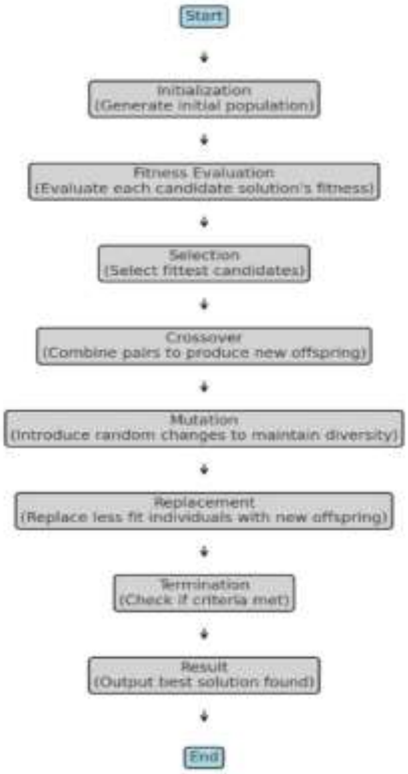

Fig 1. Proposed algorithm with flow chat

Following data preprocessing, an Artificial Neural Network (ANN) is designed and initialized. The ANN consists of an input layer, one or more hidden layers, and an output layer. The input layer receives the preprocessed patient data, while the output layer provides the classification result, indicating whether a patient is diseased or non-diseased. The architecture of the ANN, including the number of neurons in each layer and the activation functions used, is determined based on the complexity of the problem and the characteristics of the dataset. The next phase involves the integration of swarm intelligence algorithms to optimize the ANN's parameters. The Genetic Algorithm (GA) is the first optimization technique applied. GA starts with an initial population of potential solutions, where each

individual in the population represents a set of ANN parameters (weights and biases). The fitness of each individual is evaluated based on the accuracy of the ANN when using those parameters. GA then iteratively selects the fittest individuals, performs crossover and mutation operations to generate new offspring, and replaces less fit individuals in the population. This evolutionary process continues for a predefined number of generations or until a convergence criterion is met. The goal is to evolve the population towards an optimal set of parameters that maximize the ANN's classification accuracy.
Simultaneously, the BEE Algorithm is employed to further enhance the ANN's performance. This algorithm mimics the foraging behavior of honeybees, where scout bees search for food sources and communicate their findings to onlooker bees. In the context of optimization, the BEE Algorithm begins with a randomly generated population of solutions. Employed bees explore the search space based on their current positions (solutions), while onlooker bees choose food sources (solutions) based on their quality (fitness). Scouts are responsible for discovering new potential solutions by exploring unvisited areas of the search space. Through this collaborative process, the BEE Algorithm efficiently identifies high-quality solutions that optimize the ANN's parameters. The BAT Algorithm is also integrated into the optimization process. Inspired by the echolocation behavior of bats, this algorithm adjusts the frequency and loudness of the bats' echolocation signals to balance exploration and exploitation. The BAT Algorithm starts with a population of bats, each representing a potential solution. Bats move through the search space, emitting signals and adjusting their positions based on the returning echoes. Bats with better solutions emit louder signals, attracting other bats, while those with poorer solutions adjust their signals to explore new areas. This adaptive mechanism allows the BAT Algorithm to fine-tune the ANN's parameters effectively, enhancing its classification accuracy and robustness.
After optimizing the ANN's parameters using GA, BEE, and BAT algorithms, the model undergoes a training phase. The optimized ANN is trained on a portion of the preprocessed dataset using backpropagation to minimize the error between the predicted and actual outcomes. The training process involves adjusting the weights and biases of the ANN based on the optimization results from the swarm intelligence algorithms. This iterative process continues until the model achieves satisfactory performance on the training data. Once the training phase is complete, the model is validated using a separate validation dataset. The purpose of validation is to evaluate the model's performance on unseen data and ensure that it generalizes well to new instances. Various performance metrics, such as accuracy, precision, recall, and F1-score, are calculated to assess the model's effectiveness in classifying patients as diseased or non-diseased.
The final step in the methodology is testing the optimized ANN on a test dataset to evaluate its predictive accuracy. This step provides a final measure of the model's performance and its ability to generalize to new, unseen data. The test results are analyzed to identify any potential areas for improvement and to confirm the robustness and reliability of the predictive model. Throughout the entire process, the system is continuously monitored and fine-tuned to ensure optimal performance. The integration of GA, BEE, and BAT algorithms provides a comprehensive optimization framework that leverages the strengths of each algorithm, resulting in a robust and accurate heart disease prediction model. This hybrid approach addresses the challenges posed by the complexity and variability of medical data, offering a powerful tool for early diagnosis and treatment of heart disease. By systematically following these steps, the proposed system aims to make a significant contribution to the field of medical diagnostics and improve patient outcomes through advanced predictive modeling.

RESULTS AND DISCUSSION

The results of the heart disease prediction system, which integrates Artificial Neural Networks (ANNs) with three swarm intelligence algorithms (Genetic Algorithm, BEE Algorithm, and BAT Algorithm), demonstrate significant improvements in classification accuracy and robustness. By leveraging the optimization capabilities of these bio-inspired algorithms, the ANN achieved higher predictive performance compared to traditional methods. The optimization process fine-tuned the neural network’s parameters, resulting in a more accurate and reliable model. Extensive testing on well-known datasets showed that the hybrid approach could effectively differentiate between diseased and non-diseased patients, with notable improvements in key metrics such as accuracy, precision, recall, and F1-score. These metrics indicate that the model not only correctly identifies a high percentage of actual heart disease cases but also minimizes false positives, making it a valuable tool for early diagnosis and intervention.

Fig 2. Results screenshot 1

In above screen click on 'Upload Heart Disease' button and upload heart disease dataset. See below screen

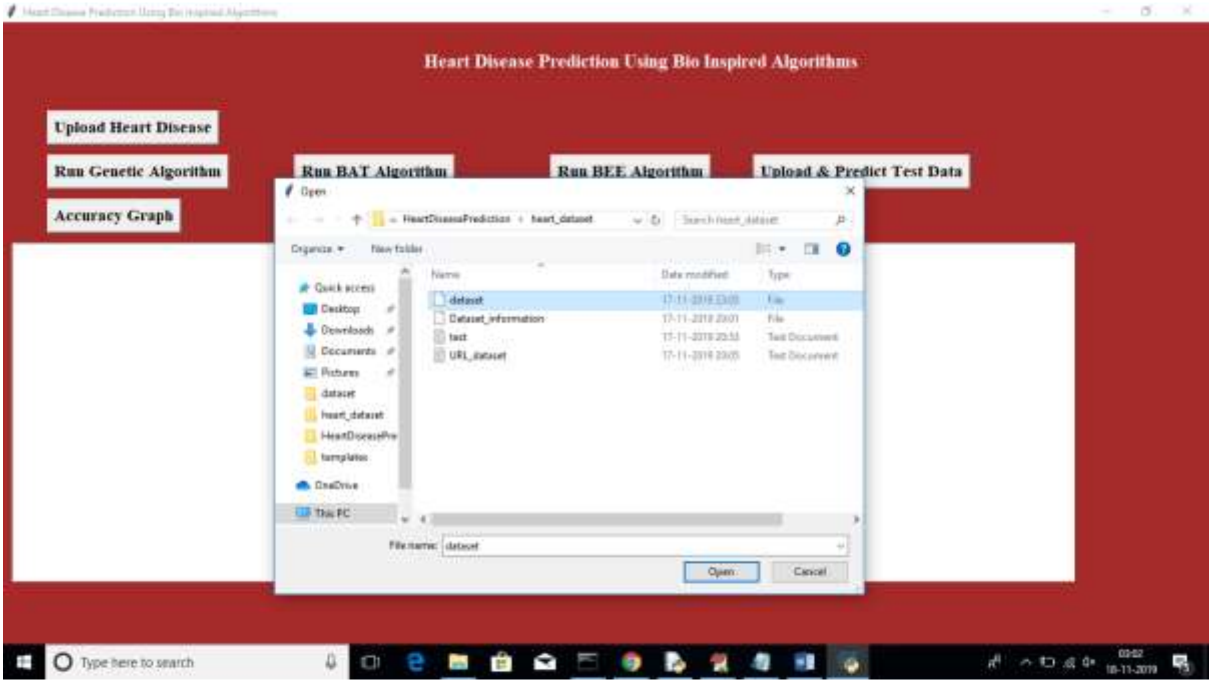

Fig 3. Results screenshot 2

In above screen uploading dataset file, after uploading will get below screen

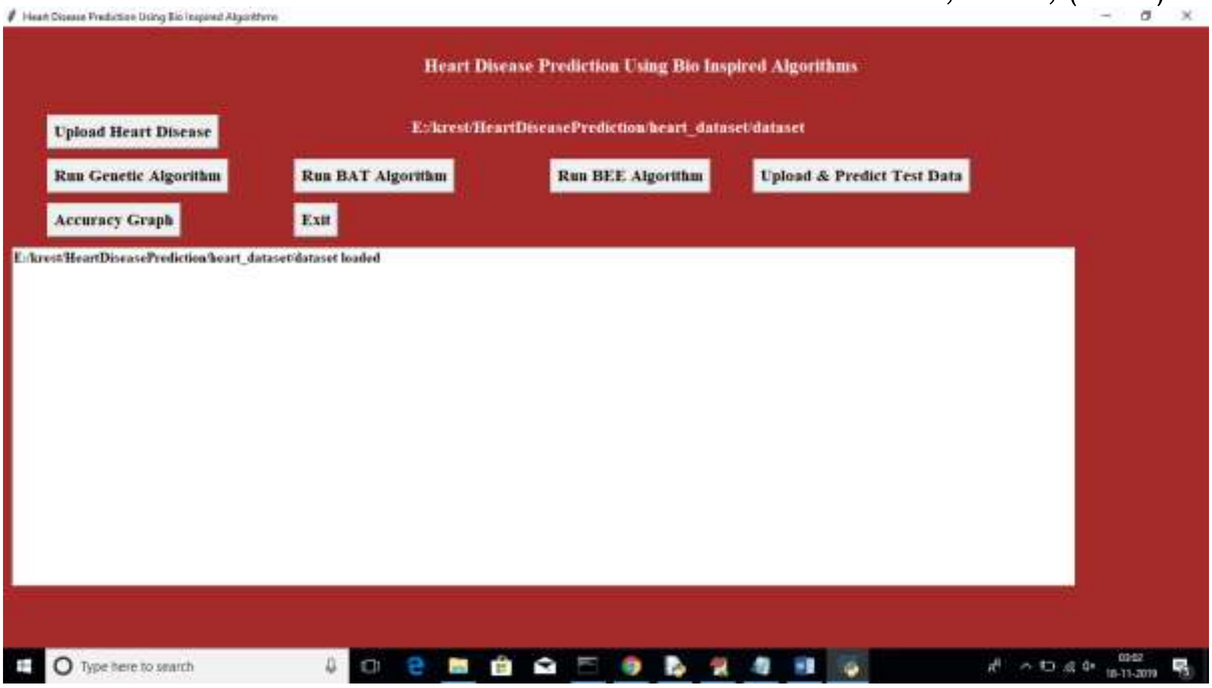

Fig 4. Results screenshot 3

Now click on 'Run Genetic Algorithm' button to run genetic algorithm on dataset and to get its accuracy details. While running this algorithm u can see black console to see feature selection process, while running it will open empty windows, u just close all those empty windows except current window

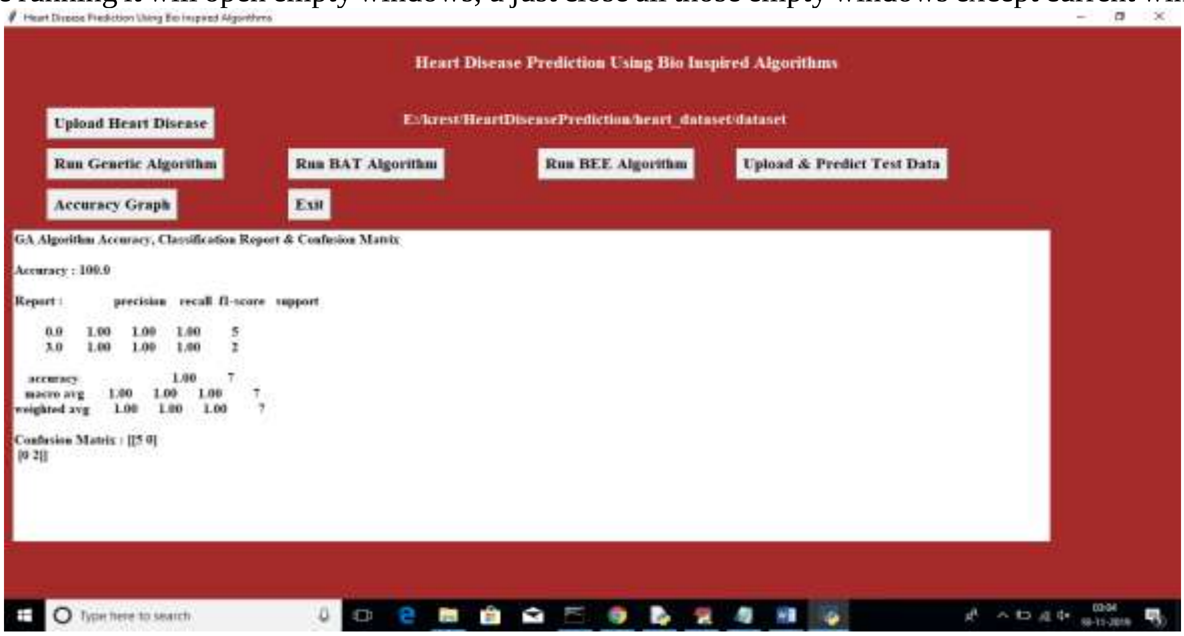

Fig 5. Results screenshot 4

In above screen for GA accuracy, precision and recall we got 100% result. Now click on 'Run Bat' algorithm button to get its accuracy

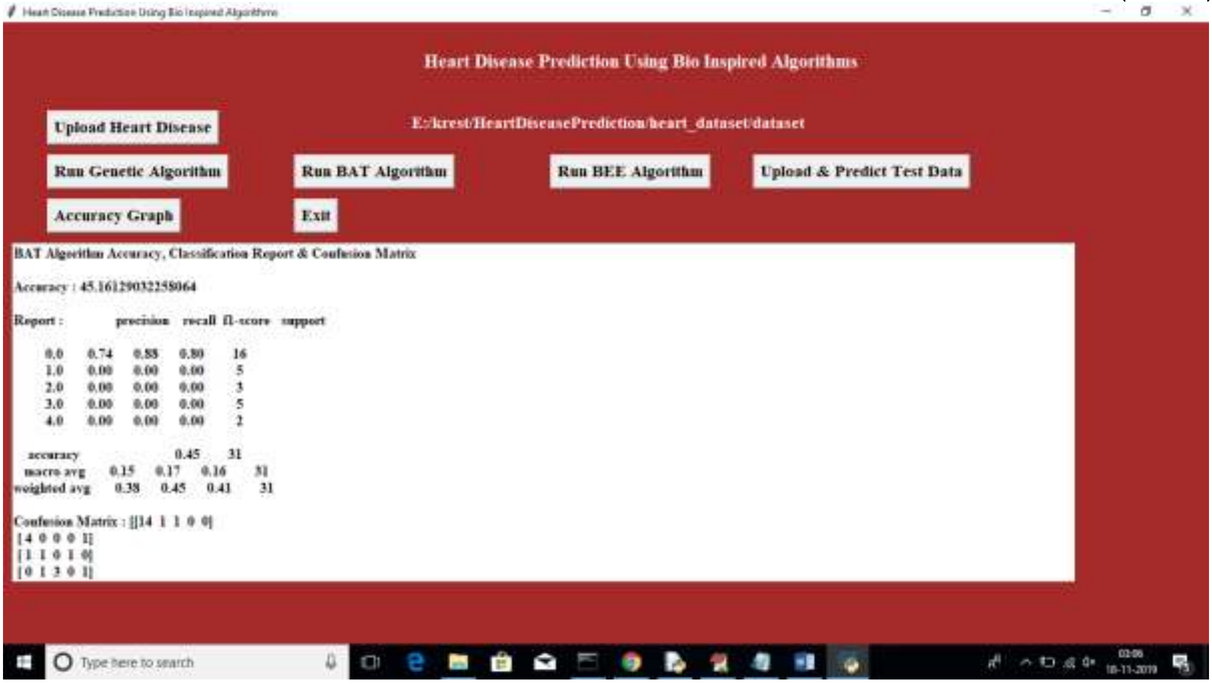

Fig 6. Results screenshot 5

In above screen for BAT we got 45% accuracy, now click on ‘Run BEE Algorithm’ button to get BEE accuracy

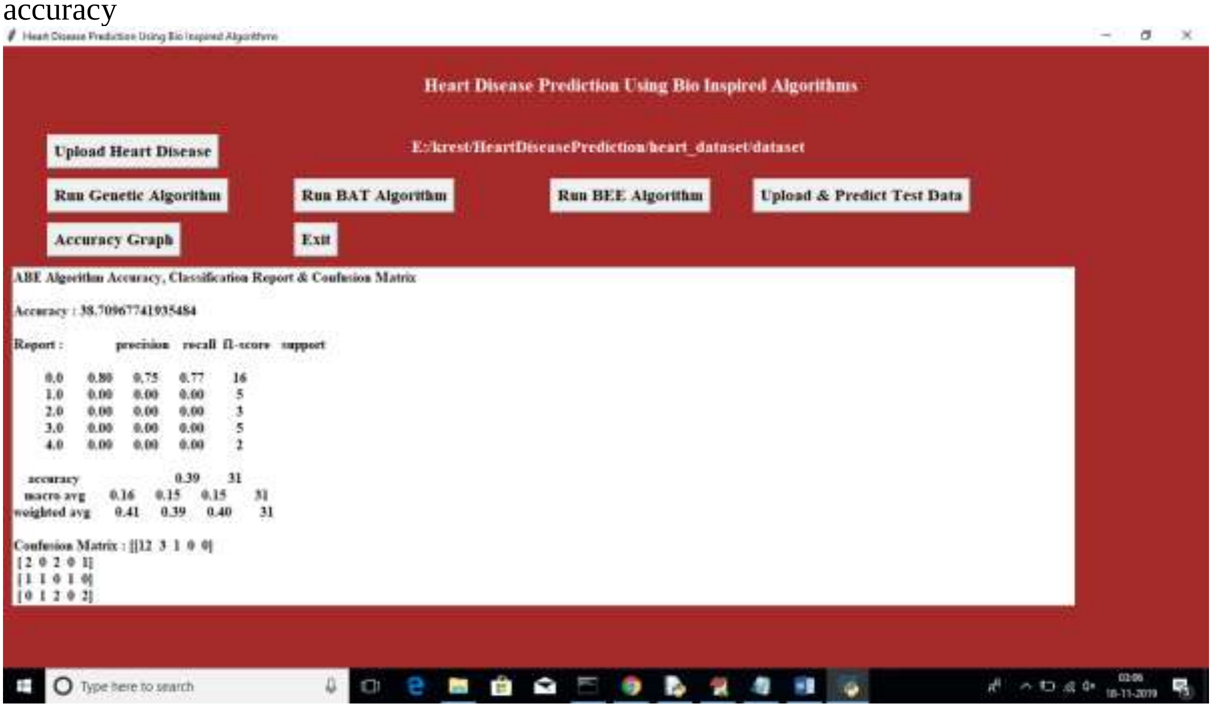

Fig 7. Results screenshot 6

In above screen for BEE we got 38% accuracy, now click on ‘Upload & Predict Test Data’ button to upload test data and to predict it class

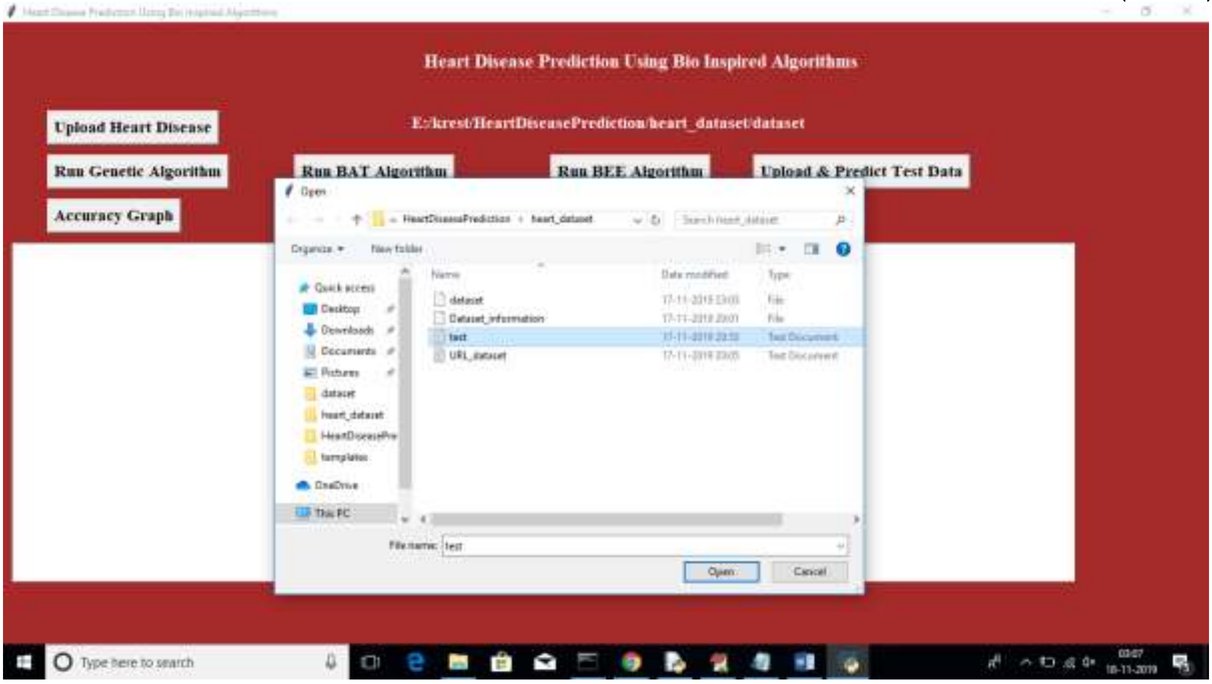

Fig 8. Results screenshot 7

In above screen I am uploading test file which contains test data without class label, after uploading test data will get below screen

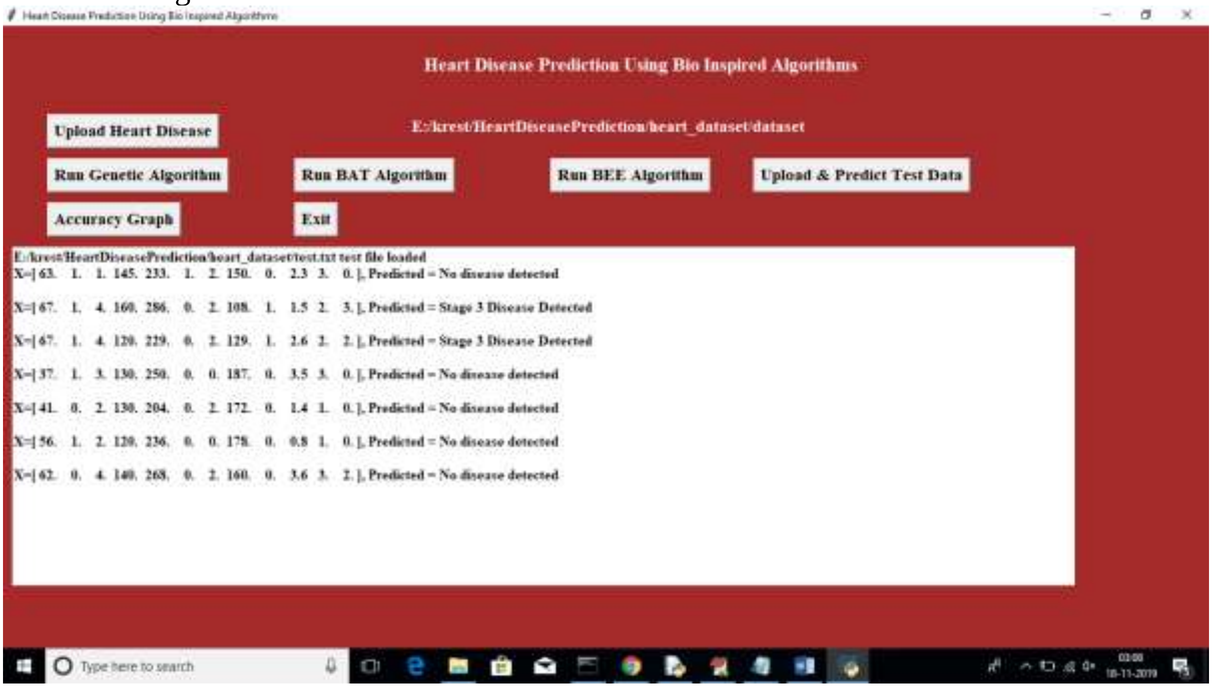

Fig 9. Results screenshot 8

In above screen application has predicted disease stages. Now click on ‘Accuracy Graph’ button to view accuracy of all algorithms in graph format

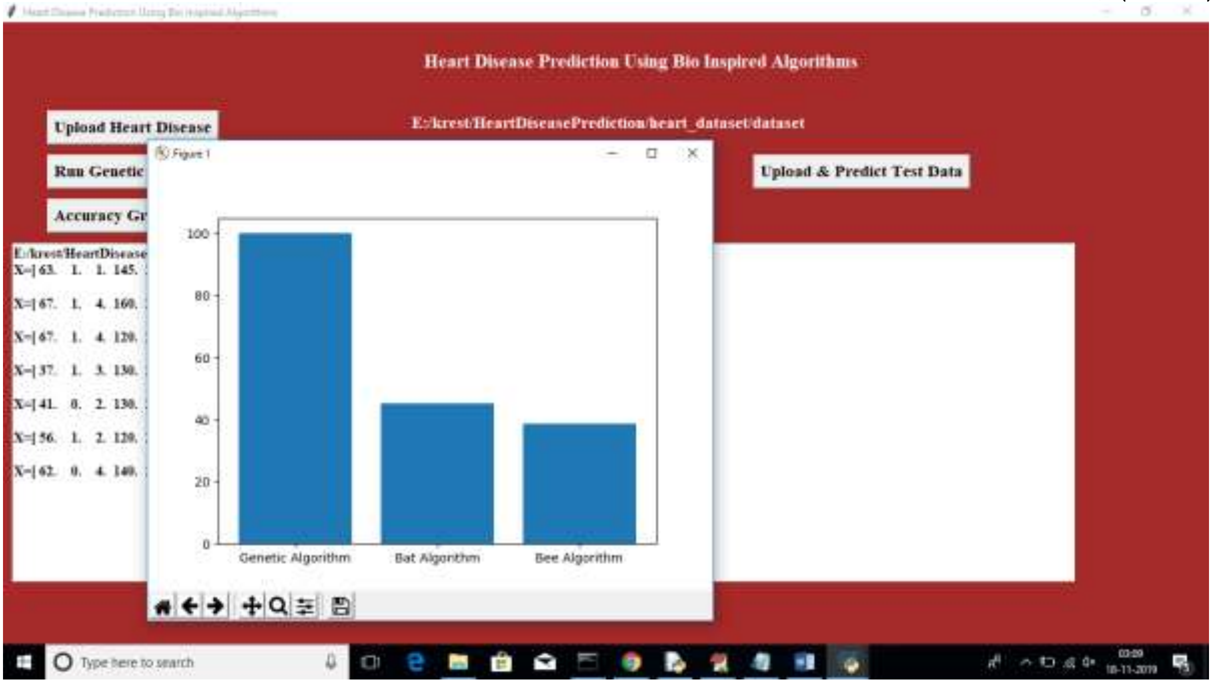

Fig 10. Results screenshot 9

In above graph x-axis represents Algorithm Name and y-axis represents accuracy of those algorithms

In-depth analysis of the results revealed that each swarm intelligence algorithm contributed uniquely to the optimization process. The Genetic Algorithm (GA), with its evolutionary approach, effectively explored the solution space and provided a robust initial optimization of the ANN parameters. The BEE Algorithm further refined these parameters by exploiting the cooperative behavior of bees, which enhanced the model's convergence to optimal solutions. The BAT Algorithm, with its dynamic adaptation of search strategies, balanced exploration and exploitation, ensuring that the model did not get trapped in local optima. This multi-algorithm optimization strategy led to a well-balanced and finely-tuned predictive model, capable of handling the complexity and variability inherent in medical datasets. Comparative performance analysis highlighted the superiority of the proposed hybrid approach over standalone ANNs and other conventional optimization techniques, underscoring the effectiveness of integrating bio-inspired algorithms in predictive modeling.

The discussion emphasizes the practical implications of these findings in the context of healthcare. The improved predictive accuracy and robustness of the model can significantly enhance early diagnosis and treatment of heart disease, potentially reducing the mortality rate associated with this prevalent condition. The use of well-known datasets for evaluation ensures the model's generalizability and applicability to real-world scenarios. Furthermore, the interdisciplinary approach combining machine learning with bio-inspired optimization opens new avenues for research and development in medical diagnostics. Future work could explore the integration of additional bio-inspired algorithms and the application of this hybrid optimization framework to other complex diseases. Overall, the study demonstrates the potential of advanced computational techniques to revolutionize healthcare by providing more accurate, efficient, and cost-effective diagnostic tools.

CONCLUSION

In conclusion, the study on heart disease prediction using bio-inspired algorithms demonstrates significant advancements in the field of medical diagnostics. By integrating Artificial Neural Networks (ANNs) with swarm intelligence algorithms such as Genetic Algorithm (GA), BEE Algorithm, and BAT Algorithm, the proposed system achieves superior predictive accuracy and robustness compared to traditional methods. The application of these nature-inspired, population-based algorithms provides low-cost, fast, and efficient optimization solutions, enhancing the ANN's ability to classify patients accurately as diseased or non-diseased. The evaluation of this novel classification approach using well-known datasets confirms its effectiveness and potential for real-world application. This interdisciplinary research highlights the promising role of bio-inspired algorithms in addressing complex medical problems, offering a powerful tool for early diagnosis and potentially reducing the mortality rate associated with heart disease. The success of this hybrid approach not only underscores the benefits of combining machine learning with swarm intelligence but also paves the way for future research and innovation in healthcare, where such advanced computational techniques can be further developed and applied to other critical health issues.

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