Prediction Accuracy Model Aiming to Improve Prediction Accuracy in Congenital Heart Anomaly Detection using Hybrid Feature Selection with Modified Particle Swarm Optimization Approach

Dr. Shaik Abdul Nabi$^1$, K.Ramya Laxmi$^2$

$^1,2$Department of Computer Science and Engineering, Sreyas Institute of Engineering and Technology, Nagole, Hyderabad, Telangana, India.
dr.nabi@sreyas.ac.in, kunta.ramya@gmail.com

Abstract. Heart Disease is one of the primary causes of mortality and morbidity in the Globe since the 19th Century. Most of the Globalized Multi-Specialty Hospitals are not able to control and governed by emerging technologies, at the same time, the death rate escalates day by day in addition to Covid-19 is a multifaceted state. Heart disease classification involves identifying numerous health problems and sickness symptoms of one's individual with significant feature selection, there is misclassification probability that could be very high and priceless. There are many diverse methods were designing for heart disease prediction systems in earlier days, even though it is unsolved and rising the death rate. As observed by many research groups, PSO is an intensive computational and inspired biologically inspired algorithms like Genetic Algorithms (GA) has a proven track record to handle computationally complex problems with competence for predicting heart diseases. This research contribution through the proposed model downs the computation time and increases the accuracy. The high-level comprehensibility, predictive accuracy are good and desired through this Intelligence Hybrid Approach (IHP) to reduce Heart attacks and control the death rate.

1. Introduction

Heart attacks are the ever-rising and causes of death around the globe. The WHO stated every time that heart attack is the first and fastest leading cause of threat as death all over the globe. Even though the technologies are evolving and occupy medical automation engineering facilities available forever. As conformance implies concerning treatment or diagnosing patients correctly and administering in a timely base that is most desired and effective element or an advanced intensive preventive step, we cannot get back the lives and time. Hospital expenses shall lower the cost of diagnostic tests and other expenses from joining to discharge from hospitals. They can control the financial and time feasibility to save from the disease. Unfortunately, these data are not supported for clinical decision-making [1]. This rings several times by all researchers and scientists that arises an important question: "Why Healthcare Practitioners do not make intelligence clinical decisions with the sorting of actual data to turn as useful information?" This is the key idea to write this research article [2].
Unsupervised learning is an aid to discovering patterns from the available specific data set, which consisting of input data without a target the labels [3]. The typical examples based on the unsupervised learning tasks are given here:

- Identifying the basic elements in Data distribution
- Bringing up to earth in Natural Grouping / Data within Data Clustering
- The Reduction process of dimensionality

To deal the data where partially labeled by using both useful partial supervised learning approach and active learning approach. The objectives have remained the same as those of Supervised Learning; However, the algorithms in this category used the unlabeled data, and they attempt to improve over the supervised learning classifiers performance, which is used as labeled data[5,6]. Active learning methods are commonly used in situations where manual annotation of data is expensive. As an objective of active learning focusses on the methods on unlabeled data is labeled next to attain the necessity of the anticipated supervised learning task with a lower number of efforts as labeled. The important task of reinforcement learning is played a key role.

The important steps of any Machine learning Cycle with the following steps.

- Start with Acquisition of Data
- As a second step as Processing of Data
- As a third step to Extraction of Features
- As a fourth step the Selection of Features and
- Supervised / Unsupervised / Reinforcement Learning Task.

The creation of appropriate feature representation is among the important steps in learning activities workflow or pipeline is a crucial role and primary objective of any model building. Before introducing the deep learning techniques, feature representation is the most handcrafted by researchers and experts in key inception. Deep learning is a better usage of feature representations with multiple levels of abstractions [7-9].

2. Literature Review

Overview of literature of Swarm Intelligence and latest applications of Swarm Intelligence algorithms were studied thoroughly and highlights are presented below. Literature includes the applications of
Swarm Intelligence algorithms like ACO, PSO, ABC, and many more latest developments. During the literature survey, the major focus was on the optimal solution of combinatorial problems such as TSP. Literature regarding ACO algorithms was the major attention during the review and concluded remarks at the end of the review discuss the same. The following section discusses the literature being studied during the research journey of the optimization of Swarm Intelligence [10].

In [3], Andries et al. employed successfully that there exists a tight relationship between the collective behavior of an individual and the individual behavior of a particle. As swarms are stochastic by nature their behavior cannot be viewed as an independent entity. Instead, their behavior is concerning to the interactions among themselves. They provide the fundamentals of Wasp Swarm Optimization (WSO) as well as Cat Swarm Optimization (CSO). In his book, Marco Dorigo et al. [4] introduced a concept of self-organizing behaviors of swarms like ants, bees, birds, and wasps, etc. Further, he states that how the foraging behaviors of ants help in various optimization problems. He proposed a metaheuristic study implemented in NP-Hard and combinatorial problems by taking the example of Travelling Sales Person (TSP) example. He has concluded that ACO algorithms can be extended to dynamic problems, stochastic problems as well as multiple objective functions. He has extended his vision to parallelization of ACO algorithms also. PSO techniques are implemented [11-14], in Data Mining tasks and compared the result of other evolutionary algorithms with proposed PSO. Standard benchmark data were used to implement PSO and result in an investigation. The authors directed the future work to achieve a balance between exploration and exploitation of PSO for more continuous data.

They conclude that for successful implementation of SI basic Review of Literature Mulani Maheshkumar Devchandbhai 32 principals as well as the dynamic problem is necessary. They gave future directions that SI can be useful for solving more complex problems. The Job Shop Scheduling Problem (JSP) was solved in [15-17] using Ant Colony System (ACS) and analyzed the experiment results. They intended to test the bee algorithms on semiconductor manufacturing scheduling problems. They gave directions for the development of hybrid methods in the future. They have applied a PSO model to deal with multimodal optimization problems. They employed the best result for the proposed PSO algorithm in comparison with others. They conclude that the proposed algorithm showed better results for non-linear equations modeling the traditional numerical optimization problems [20,21].

S. Talukder [18] demonstrated the mathematical modeling of particle swarm optimization and its applications. He employed various algorithms for varieties of PSO and developed a mathematical model based on specific applications. He gave various applications of PSO like Antenna Design, Signal Processing, Networking, and Robotics. He gave future directions for optimization of the nonconvex optimization problems.

S.Chu et al. [19], reviewed and verified popular algorithms based on swarm optimization especially PSO algorithms. Various improved versions of algorithms are described. They employed popular test functions for traveling salesperson problems for simulation experiments. K. Socha [22] presented ACO for dynamic optimization problems having continuous and mixed variable domains. He developed a model and implemented a benchmark test problem for the Pressure Vessel Design problem.

3. Methodology

3.1. Swarms and their biological behaviors

The French entomologist Pierre-Paul Grasse observed in the early ’40s & the late ’50s of the 20th Century, that some species of termites react to what he has titled as “significant stimuli”. Grasse used the term stigmergy.

- The study of swarms includes the behavior of organisms like ants, bees, termites, fish, and birds. Swarms are stochastic, random, and self-organizing in their nature. There exists a tight relationship between the collective behavior of an individual and the individual behavior of a particle.
- As swarms are stochastic by nature their behavior cannot be viewed as an independent entity. Instead, their behavior is concerning to the interactions among themselves considered.
3.2 Computational Swarm Intelligence
An optimal solution for combinatorial problems, which are NP-Hard in nature, is difficult to achieve using traditional algorithms as well as evolutionary algorithms. Based on the Swarm Intelligence concept various meta-heuristics are being developed which are generally termed SI Models. Some of the models have shown promising behavior and are widely used in the field of optimization. The next section describes the Swarm Intelligence models and their computational significance [14]. Various hybrid approaches are also there to optimize the performance of GA and PSO. The 2-opt local search technique is one such technique that was implemented to enhance the overall prediction accuracy of GA and PSO [18]. The self-organizing and stigmergic behavior of real ants is implemented using the probabilistic transient rule and pheromone evaporation rule. The velocity update rule is used to implement the PSO algorithm. A combinatorial problem, Travelling Sales Person (TSP) is chosen as a case study to implement the basic approach of GA and PSO and hybrid as well. During the implementation, the problem found is that the locally optimal solution is achieved but after that, is stuck into stagnation phase where the solution cannot be optimized more [23-26].

3.3. Genetic Algorithm
GA is one of the types of key searching algorithm, which works on a population of people to find the accuracy in any classification to use in prediction. The set of a group of candidate solutions is named as population, consider during the key of revised the algorithm. Parents are given as birth for few new members into the population to the further generations in the algorithm, while few others may die. An individual may be referred to as a unique solution in the population and the fitness of an Individual is consider as to how "Good" by the Individual. The higher fitness- the significantly the better solution, this is dependent on the problem to be given as a solution for better accuracy. The algorithm has a multi-objective function that gives some complexity and "evolves" many numbers of iterations to find feasible better solutions [27-31].

4. Hybrid Feature Selection with Modified Particle Swarm Optimization Approach
We have proposed a combinatorial hybrid approach in which PSO with GA to the appraisal of the better accuracy of the result. As a first step, we initialize the random selection of particles and looking for a feasible optimized solution. Further, the identification of fitness values titled Pbest and a global value Gbest or Lbest by updating of particles with its fitness function. Whereas the updating of each particle in a population is updated in PSO, but Crossover and mutations did by comparing the individual particles with another whole cluster of data or particles results in one bundle towards a useful optimize area in GA Process [32,33]

4.1. Feature selection
Feature selection is a process of avoiding unnecessary duplication of attributes from the selected datasets based on the assessment deserving criteria for the improvement of accuracy. The major approaches in feature selection of an evaluation assessment. The classification is in terms of three broad classes, namely filters, wrappers, and embedded methods which are based on attribute selection deployment with the aid a supervised learning algorithm [32]. PSO relies upon the principle of each solution and is represented as an individual particle in the population of the swarm. Each individual with respective a position velocity in the search space and denoted by a vector

\[ Y_i = [Y_{i1}, Y_{i2}, Y_{i3}, \ldots, Y_{iD}] \] (1)

Where D is the Dimensionality of the Search Space. The Particle moves in the search space to look for feasible solutions. Each Particle has its Velocity is represented as

\[ U_i = [U_{i1}, U_{i2}, U_{i3}, \ldots, U_{iD}] \] (2)
During the particle movement, and comparison of individuals, each individual enhances its orientation and accessibility according to the learning ability of its own and its neighbors. The Gbest, Pbest is identified through an iterative process [34,35]. Proposed object detection using a multi-box detector for small objects [36-41].

### Table 1. Feature Selection of the Data Sets 1 Class label with 279 Instances

| Feature       | Description                                                                                                                                 |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Age           | Age in years                                                                                                                                 |
| Gender        | Gender (male, female)                                                                                                                       |
| Dulhare       | 2647 Biomed Res                                                                                                                           |
| Cp            | Chest Pain Type (Cp- Typical Angina / Cp- Atypical Angina / Cp- Non-Angina, Cp- Non-Anginal Pain, Cp- Asymptomatic)                         |
| Trestbps      | Blood Pressure (On Admission to the Hospital measured In MmHg) resting                                                                       |
| Chol          | Serum in Mg. / Di Fbs Fasting Blood Sugar > 120 Mg / Di (T/F) Cholesterol                                                                    |
| Restecg       | Resting (Normal / Abnormal / LVH) Electrocardiographic results                                                                               |
| Thalach       | Achieved Heart Beat Maximum                                                                                                                |
| Exang         | Y/N, Induced Angina Exercise                                                                                                               |
| Oldpeak       | Exercise Relative to the rest of ST Depression Induced                                                                                     |
| Slope         | ST Segment (Slope / Unsloping / Flag / Downsloping) of the load exercise                                                                   |
| Ca            | Fluoroscopy Number with Major Vessels (0-3)                                                                                                 |
| Thal          | Reversible / Fixed Defect / Normal                                                                                                          |
| Num           | Y/N Heart Disease                                                                                                                          |

The multiple objective functions as follows with the help of mathematical formula for reducing the cost is:

\[
\text{Minimize } F(Y) = [F1(Y), F2(Y), F3(Y), \ldots, Fk(Y)] \quad \text{(3)}
\]

\[
\text{Subject To: } Gi(Y) \leq (0, I = 1, 2, 3, 4, \ldots, M) \quad \text{(4)}
\]

\[
Hi(Y) = 0, I = (1, 2, 3, \ldots, L) \quad \text{(5)}
\]

Where the Decision variable is represented by X, the mathematical function of Y is Fi(Y), is identified by K to be minimized, Gi(Y) & Hi(Y) are the constraint functions of the problem. We revised the methodology to raises up in the prediction accuracy of Genetic Algorithm and PSO for better prediction with input data sets as Heart Disease and classified the Patient dataset is into the Heart Disease is there or normal.

4.2. Flow chart of the proposed method

To summarize PSO, we can state that the particle actions into the move according to its own position and with respect to its best neighbor and best global location of a swarm as well. The best value is chosen based on the basis of the search solution and the fitness function of the problem taken into consideration.

The best global location is derived from the best local solution which is better with the fitness value. The best local and global solutions are also selected based on the fitness function that should best be suited for the problem. The problem under consideration can be either minimizing the cost or maximizing it, especially for an optimization problem.
Here the algorithm representation of elements of every vector orientation is given as dimension, the particles consist of vectors of real numbers, which can be described from the operations on a total cluster of individuals titled as particles. Every individual particle evolves using 2 appraised formulas as the acceleration of particles and its orientation.

**Improvised FS-PSO Algorithm :**

1. Start The Process.
2. Particles Initialization Process.
3. Each Particle Fitness Values Assessment to be done
4. Assign the new Pbest Value; If The CV of Particle > The Pbest
5. Keep the previous Pbest Value; If The CV of Particle < Than The Pbest
6. The Gbest identification done through Assign Best Particle Pbest Value.
7. Begin again the Initiation of the Crossover function.
8. Mutation processing start to be done
9. Decision of identifying prediction whether true or false , Final Result is achieved
10. End of the Process

**Figure 2.** Flow Chart of Hybrid Feature Selection with Modified Particle Swarm Optimization Approach (MPSOA)

**Fig 3.** Improvised Hybrid Feature Selection with Modified Particle Swarm Optimization Algorithm
4.3 Pseudo-Code of MPSOA

| i.  | Initiation                                                                 |
| ii. | Segregate the dataset as Training and Testing parts;                       |
| iii. | Initialize each particle in the swarm with the position & velocity         |
| iv.  | While look at the max Iterations is not met do                              |
| v.   | Identify the major objective values either true or false of every particle with a classification rate |
| vi.  | Swarm based solutions that has non-dominated solution particle or dominated solution particle; |
| vii. | Non-domination of Each particle crowding distance of individual calculation to be |
| viii. | Go to the identification of crowding distance based on the non-domination and sorting particles necessity |
| ix.  | Group up all the particles in the swarm                                     |
| x.   | For i=1 to population Size (PS) do                                          |
| xi.  | Appraise the Pbest of individual i;                                         |
| xii. | Selection in randomly a Gbest for individual i from the maximum rank and less crowded solution in non-domination; |
| xiii. | Particle ‘i’ position and velocity updation                                 |
| xiv. | Appraise Particle i To Union is to be added;                                |
| xv.  | end 10                                                                     |
| xvi. | Identify Different Levels Of Non-Dominated Fronts F = (F1, F2, F3, ...) In Union; |
| xvii. | Make empty the CV Swarm for further Iteration;                             |
| xviii. | i = 1;                                                                    |
| xix.  | while ( |swarm| < PS ) do                                                   |
| xx.   | if ( |swarm| + |Fi| ≤ P ) then                                               |
| xxi.  | Add Fi to Swarm;                                                         |
| xxi.  | i = i + 1;                                                                |
| xxii. | end 16                                                                    |
| xxiv. | if ( |Swarm| + |Fi| > P ) then                                               |
| xxv.  | Evaluate crowding distance in Fi;                                          |
| xxvi. | Sort individual in Fi;                                                    |
| xxvii. | Add the (PS – |Swarm|) Minimum Crowded Particles to Swarm;                  |
| xxviii. | End 24                                                                   |
| xxix. | End8                                                                     |
| xxx.  | End 3                                                                    |
| xxxi. | Evaluate the classification rate of the error rate in feature subsets in the Fi on the test set return the positions of individual Fi; |
| xxxii. | Return the classification rate of error in training and test of the solutions in Fi; |
| xxxiii. | End                                                                       |

Figure 4. Pseudo Code of Modified Hybrid Feature Selection with Modified Particle Swarm Optimization Approach (MPSOA)

Iterations are used to search the solution and save the best-fit position for particles as “Global best”, Gbest model and significant identification of goodness value met by each individual “Personal best”, Pbest is also stored[29]. To simplify further to get intensive classification in the proposed approach is the constraint-handling. It relies on the constraint as a “feasible and optimal particle is
preferred over an infeasible and in optimal one”. Every iteration of this algorithm uses the constraint-handling scheme when the Pbest and Gbest individuals chosen to carry out after enhancing each particle in the swarm and before the selection of new values for Pbest and Gbest individuals.

The description of the entire method working is explained below:

- Feasibility of the Particle Case with the new value of the Particle updation based on the corresponding Pbest is infeasible; then the Pbest.
- Infeasible of the Particle Case with No change is made based on Pbest is feasible then it does not get change.
- One Feasible and Other Infeasible both Cases then one closer region is chosen, based on particle and pbest are infeasible.

The case of an individual is found to be feasible, shows good performance in a positive way, otherwise, every particle is identified as to be infeasible, and the sum of their constraint exceptions as the value is evaluated or examined with respect to large deviation stored and treated as in consideration as a feasible distant region. The identical process of selection is continuing at every iteration of the algorithm.

5. Results

The results were generated by simulation tool for the PSO Hybrid Algorithm and optimized GA having various input parameters and a varied number of iterations. Initially, the .CSV datasets are taken for testing. The optimal parameter setting of Alpha, Beta respectively.

Table 2. Summarize performance of PSO with standard data sets

| S No | Nor of Classes | Hybrid - PSO | GA      | Optimized PSO&GA |
|------|----------------|--------------|---------|------------------|
| 1    | 23476          | 414677       | 417143  | 459876           |
| 2    | 25445          | 188823       | 178846  | 222965           |
| 3    | 15434          | 292732       | 319231  | 326563           |
| 4    | 2221           | 42437        | 42279   | 49148            |
| 5    | 9845           | 205431       | 196756  | 248178           |

Table 2 shows different classes of the data sets with any number of instances are executed the heart disease classification done in every individual particle as a record PSO is slightly decreasing accuracy, but GA gives better results also gives results not up to the expected optimality. After combining these two techniques more accurate results have been shown. The Performance Analysis of Hybrid PSO, GA & Optimization Algorithms in the above Fig. On X-axis and % results of accuracy on Y-axis. We can observe that the graphs are clearly shown PSO & GA graphs are similar to that Optimization with GA. It is proved that the combination algorithm means optimization algorithm accuracy increases as compare with PSO & Genetic.

To obtain good accuracy and prediction, we used the open-source statistical tool R with Caret, and packages of PSO are selected. The proposed Optimization with PSO &GA search iterations are shown with respect to accuracy in the above table.2 and the below-mentioned figures. Where we can observe the accuracy of 88.91% is a record at the maximum number of iterations also shown 100%. We have identified in the combined approach as the result is on convergence number of iterations can be stopped with negligible deviation in the convergence.
Figure 5. Datasets for feature selection

Figure 6. Heart Disease
Figure 7. Performance Analysis of PSO & GA

Figure 8. No Heart Disease

Figure 9. Accuracy of PSO&GA
6. CONCLUSION
The benefits of combined algorithms like PSO & GA with various feature selection is always an advantage to solve multivalued objective functions. It gives good prediction accuracy with these Hybrid approaches. The study motivated us to develop automatic API misuse detection techniques, which can help developers to find the misuse of machine learning and deep learning programs. It is observed the datasets are very much useful in misuse directness and imbalance that prior confirmed to research. We can conclude that the simulation results are analyzed that automatic evolvement of subset formation with a minimum number of features and to improve the classification performance of data sets. Further scope is to be optimized the better way the combination few more algorithms with the help of combinatorial search with feasible feature selection of the available resources.

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