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Classification techniques based on Artificial immune system algorithms for Heart disease using Principal Component Analysis

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ABSTRACT

The modern era is a period of machine learning, which helps in finding new facts for future predictions. Classification is a machine learning tool that helps in the discovery of knowledge in Big data and it has various potential applications. Researchers nowadays are more inclined to the techniques which are inspired by nature. The artificial immune system (AIS) is such a method that is originated by the qualities of the humanoid immune system. In the proposed method, artificial immune stimulated classifiers as supervised learning methods are used for classifying Heart disease datasets. The performance of the classifiers strongly depends on the datasets used for learning. Here it is observed that, when the principal component analysis is performed on the standard dataset, then classifiers' accuracy and other facts show improvement in performance, which leads to fall in errors.

Keywords: Classification, Machine learning, Supervised learning,Artificial immune system, Principal Component Analysis.

I. INTRODUCTION

Big data analysis is the trending and immerging field of computer sciences. In the modern computational world, Machine learning [19] and deep learning are used as tools for data analysis and data mining applications. Data mining [11] is the methodology applied in the area of information generation, which can be utilized in the future for long term decisions. Classification is the data mining method of predicting the nature of the item, based on the data given related to the other entities. Classification can be done by using various methods like decision tree, rule-based methods, memory-based methods, Bayesian network, neural network, etc. New nature motivated technologies are immerging nowadays, where researchers are interested in the application of those techniques in the computational field. The field of Artificial Intelligence [11] is explored into various techniques for improvement in the performance of the system, such concepts can be like genetic algorithm, swarm intelligence, fuzzy logic, and soft computing i.e. artificial neural network [13] and artificial immune system [17].

The proposed method contains various artificial immune system (AIS) algorithms as classification techniques for predicting class attributes of the dataset. Effectiveness of various AIS classifier algorithms with a combination of principal component analysis (PCA) as a preprocessing method for patients of heart disease is done for relevant observations.

Firstly, an experimental evaluation environment is established by the major steps like environment setup, performing data normalization, and data conversion if required. Proper Data mining methods are selected to improve the performance of class prediction. Secondly, the various artificial immune system based algorithms are selected which are majorly classifiers in the three categories, i.e. AIRS (Artificial immune recognition system), Clonal selection, and immune network algorithms. Finally, the reprocessed data sets are applied to the algorithms initially the normalized data is executed and results are calculated and in the next step Principal component analysis filter is applied to the dataset, and resulted figures are observed. Observation is useful in the selection of the best AIS algorithms for the datasets for future prediction of the class.

The organization of the paper is as follows: section 2 discussed some early research in the classification and artificial immune system. Section 3 describes the experimental setup and data preprocessing applied. Experimental details are displayed in Section 4. Research is concluded in Section 5 and references are listed in Section 6.

II. RELATED LITERATURE

A. STATE OF ART

The artificial immune system is the computational learning method which is adopted higher qualities of the human immune system (HIS). Dasgupta [31] has introduced a multilevel immune learning algorithm (MILE) which combines several immunological features. AIS [2] has become a popular area of human-inspired computational intelligence techniques. Watkins and Boggess [26] developed a classifier from the principle of the resource-limited artificial immune system i.e. artificial immune recognition system algorithm (AIRS), which shows the performance comparison of various data sets of public interest.

B. CLASSIFICATION

Reddy et al. [18] define Data mining as a method of extracting useful patterns and information from the huge amount of data records, which is helpful in further decision making.

Canedo and Romariz [28] explain classification as supervised learning technique used to analyze data sets and take each instance of it and assign the class to that record in the dataset. Various commonly used classification techniques are Bayesian networks, decision tables, IBK, J48, MLP, and Naïve Bayes. Jason [30] defines classification as a process that includes model generation by applying the training data set, then the generated model is tested by executing it on the test data set and comparison of calculated results with required results produces accuracy and errors in the model, finally the model with the highest accuracy is considered a significant approach.

C. ARTIFICIAL IMMUNE SYSTEM

Nino et al. [30] state that the human immune system (HIS) is well-designed and conceptual. The main operation of the biological immune system, is to identify, encountering objects as known objects called Self or unknown objects as Non-self. Non-self are the element like bacteria/viruses/tumor cells which are harmful for the body and must be removed immediately. Self are the useful elements required for the proper functioning of the body organs and they must be kept undamaged. The immune system can identify antigens. They are the fundamental elements associated with both body cells and external cells as pathogens (bacteria). Antigenic patterns on the surface of cells elaborate on which objects are Self /Non-self [15].

Castro and Timmis [8] specifies the body organs that participate in the human immune system, according to them, several organs and types of tissues are around the body such as lymphoid nodes, lymphatic vessels, tonsils, and adenoids, bone marrow, thymus, spleen and Peyer's patches participates in the immune activities. Types of lymphocytes are B cell and T cell, their function is to observe and recognition of antigen patterns.

Jason et al. [10] explained characteristics of the HIS which can be implemented as computational methodologies, termed as artificial immune system (AIS), for performing data manipulation. Forest et al. [13] have given a detailed view of implementation areas of AIS are Computer Security as anomaly identification, Digital forensic, Data Recognition, Robotics, Problem optimization, Fault Tolerance, Expert Systems, and Mechanical designing. Different AIS models are as below:

i) *NSA (NEGATIVE SELECTION ALGORITHM):* Forest et al. [12] proposed the Negative selection concept, which is originated by the characteristics of Thymus, which produces several T-cells, which are engaged in the identification of non-self-antigens entering into the body [26]. The initial stage of this process is to deliver a set of known objects as self S. Next step is to create a set of detectors, D, that just perceives the complement of S [11]. Junyuan Shen et al. [3] stated that these detectors can be useful on a test informational collection to characterize them as self /Non-self.

ii) *CLONAL SELECTION ALGORITHM*: Burnet [16] proposed the clonal selection concept, it is the procedure of identification of antigen, multiplication of cell, and separation of memory cells. Castro and Zuben [14] named the Clonal selection algorithm as CLONALG, for learning and improvement. The main operation of CLONALG is to generate antibodies that act as memory cells that perfectly similar to the members.

iii) *IMMUNE NETWORK MODEL*: Jerne [9] defines an immune network algorithm to impose the learning properties of the natural immune mechanism. The rationale behind the concept is that any lymphocyte receptor inside an entity can be perceived by a subset of the absolute receptor category. Human Immune systems are frequently alluded to as an idiotic arrangement. This concept likewise clarifies the immunological practices, for example, resilience and memory rise. AINE (Artificial Immune Network) is named as a new conceptual algorithm AIN (Artificial Immune Network).

iv) *DANGER THEORY:* Another immunological model, recommended by P. Matzinger [5], states that the safe framework doesn't recognize self /non-self-objects. It differentiates among the category of hazardous and safe by acknowledgment.

D. RELATED LITERATURE

Akinwande and Abdullahi [22] has presented a concept of an artificial immune system in the classification of crops principal component analysis is used as a filtering technique in the paper, by the statement, it is concluded that the AIRS1 algorithm is effective and gives accurate results.

Cruz et al. [24] implemented principal component analysis with a genetic algorithm (PCA-GA) for a classification model for crops. They applied crop classification for datasets like soybean, cassava, and mushroom, and found that PCA-GA optimizes the classification process.

K.Polat [23] introduced an expert system based on principal component analysis (PCA) and adaptive neuro fuzzy interference system (ANFIS) to analyse diabetes disease dataset.

III. AIS TECHNIQUES

AIS is connected with abstracting the structure and capacity of the organic insusceptible system to solve different and complex problems [31]. Several AIS algorithms based on the characteristics of biological immune systems are AIRS1, AIRS2, AIRS parallel, Clonal selection algorithm (CLONALG), Clonal Selection Classification Algorithm (CSCA), Immunos1, Immunos2, and Immunos99 [19,30]. These algorithms are utilized in abnormality identification, design coordinating, design acknowledgment, optimization, and so on.

A. CLONALG (CLONAL SELECTION ALGORITHM)

Castro and Zuben [14, 33] proposed CLONALG which is, about preparing of data standards and describes an overall learning methodology. This technique incorporates a population of versatile data with a populace of fixed size exposed to a serious procedure for determination, which, along with the resultant cloning and transformation, in the end, it improves the information units of the system to their environment.

B. CSCA (CLONAL SELECTION CLASSIFICATION ALGORITHM)

CSCA is shaped by Jason B. [30], it is designed to reduce the number of incorrectly classified instances from the datasets. The clonal selection classification algorithm (CSCA) has been planned to utilize clonal selection which is utilized to safeguard the living being from intrusion. The first algorithm develops an antibodies memory pool, which characterizes a solution to the fault diagnosis problems. CSCA was trained for various generations, and during each generation, the whole arrangement of antibodies is presented to all antigens. The primary target of the clonal determination classifier is to maximize prediction accuracy.

C. ARTIFICIAL IMMUNE RECOGNITION SYSTEM(AIRS1)

Watkins and Boggess [26] introduced AIRS, as a cluster-based method for classification. Firstly, it trains for input space by designing a cluster center of it and then by applying K nearest neighbor for classification of values with the center. It is the idea of assets originates from earlier work on AINs, where an individual cell ARB (Artificial Recognition ball) is actually a group of comparable cells. ARB cells stimulate to the identification of the input patterns and the number of similar (clones) cells they can create. [6]For real-valued vectors, an affinity measure between input designs is characterized as the Euclidean distance formula as follows:

$$\textit{Euclidean distance} = \sqrt{\sum_{i=1}^{n}(x-y)^2} \quad (1)$$

Where,

n represents the number of characteristics,

x is an information vector

And y is a cell vector.

During cloning (somatic hypermutation) various cells are conversely relative to the incitement of an offered cell to information design. The AIRS algorithm has various user-configurable parameters for adjusting the training schedule for a particular problem space. Training data is represented by AIRS pool or memory cells (information models) training data is represented by them and it is also perfect for classifying unknown data.

D. ARTIFICIAL IMMUNE RECOGNITION SYSTEM (AIRS2)

Artificial immune recognition system (AIRS1) [8] further investigated for a generation of the canonical version which is known as the artificial immune recognition system second i.e. (AIRS2). It is an immune motivated algorithm which uses the concept of bone-marrow and clonal selection, Jason B. [30]. This algorithm uses a population control mechanism by applying an affinity threshold for the learning process. It provides better generation capability due to the methods applied for data reduction on training sets.

E. IMMUNOS-1

Immunos-81 was the first immunos algorithm proposed by Carter [15], implemented the concept of AIS for classification. It is further configured into different forms Immunos-1 and Immunos-2 and the extension of the algorithm is known as Immunos-99. This algorithm is based on the AIN algorithm concept given by Jerne [9], Immunos1 algorithm is based on no data reduction, and here the generated clone population is used for classifying new datasets.

F. IMMUNOS-2

Immunos-2 is based on the first algorithm i.e. immunos81 algorithm developed in the series of artificial immune network algorithm, the Immunos-2 usage is the same as Immunos-1 the just contrast is it tries to give some type of essential speculation using population decrease and in this way a closer portrayal to the first Immunos-81 algorithm.

G. IMMUNOS-99

The algorithm Immunos99 [1, 30] is also called an Immunos-inspired algorithm it also implements features of the clonal selection classification algorithm. It used the full benefit of Immunos-81 and also implies cell-proliferation and hypermutation techniques. Results show predominantly in data reduction and an overall harshness toward calculation boundaries. We use complexity functions to reason about relative execution times, autonomous usage varieties.

IV. EXPERIMENTAL RESULTS

The proposed method is used to analyze disease datasets for the classification purpose which will help in identifying the class of patients, with high risk. Accurate classification of patients supports in further treatment. Classification is the appropriate method to analyse the dataset for disease prediction.

A. EXPERIMENTAL SETUP

Tests are conducted on the Laptop with Windows 10 Pro (Intel Core (TM) i3, 4 GB RAM), software tools used for the experimental purpose was WEKA version 3.8.4 and Weka classalgo version 3.6.4. Weka is a proficient information mining software with immense scope of examination measures. It has capacities of investigating information utilizing methods like Classification, Clustering, Association and Attribute selection.

B. DATASET

The selection of dataset is from standard online available the machine learning UCI repository, for analysis purposes datasets are available in .arff or .cvs. Table I, shows a detailed description of the dataset.

TABLE I: DATA SET USED IN THE EXPERIMENT.

Dataset Name	No. of attributes	No. of Instances	No. of Class Values
Heart disease	14	303	4

C. DATA PREPROCESSING

Pre-processing is carried out to remove noise or useless data that will not contribute to the accuracy of the classifier. The irrelevant or redundant features can result in high computational cost, high memory usage, and reduced performance on the accuracy of the classifier. The normalization of the data set is done on the [0, 1] scale. When required data values are also converted into numeric to nominal.

D. FEATURE EXTRACTION PROCEDURE

In the proposed method, Principal component analysis is used as a filtering technique [23]. PCA breaks down the connections among multivariable, looks for the important parts signified as a straight mix, and clarifies the whole changes with a few segments. The point of PCA is to make the necessary dimension reduction for the appropriate selection of features by using linear equations [33]. If the original dataset is consists of p number of components or variables, although only k number (less than p) of variables are required, for the perfect representation of the same information as p variable and n attributes denotes in actual datasets. These set of k variables representing p, and having n attributes are known as principal components. It can be represented as a set of observed vectors {xi}; where i ∈ {1… n} and let the m be principal axes {yj}; j∈ {1… m} are the orthonormal axes for maximizing retain variance under projection. It is identified that m dominent eigenvector of the covariance matrix representing vectors yj which is a set of largest associated eigenvalues.

E. EXPERIMENTAL RESULTS

Firstly, the data is normalized and classifier algorithms are executed on the dataset and secondly, the principal component analysis feature for 5 main features is applied, then classification process is executed on the normalized and filtered dataset. Various Artificial immune inspired algorithms are considered as classifiers in the experiment, as:

i) CLONALG
ii) CSCA
iii) AIRS1
iv) AIRS2
v) Immunos1
vi) Immunos2
vii) Immunos99

Every above classifiers are analysed on the 10 fold cross validation mode.

The classifiers are analysed with normalized data set and experimental results of all the algorithms on the bases of TP rate (True positive rate), FP rate (false-positive rate), Precision value, Recall value, F-measure, ROC CURVE (Receiver Operating Characteristics) and RMSE (Root Mean Square Error) are given in Table: II, here the results of experiments are without application of principal component analysis filter on the dataset.

In Table: III experimental results are displayed after applying normalization and principal component filter. Results are displayed on the bases of TP rate, FP rate, Precision value, Recall value, F-measure, ROC curve and RMSE.

From the above tables II & III, by comparing values of TP rate, FP rate, Precision, and Recall values, it is observed that after application of principal component analysis, the performance of the algorithms CSCA, CLONALG, AIR2, Immunos1, immunos2, and Immunos99 are remarkably improved and error rates of the classification process is also reduced.

Below table IV shows the percentage of correctly and incorrectly classified instances of different immune inspired classifiers on the dataset without PCA.

Correctly and incorrectly classified instances in terms of percentages are shown in table V, here the dataset is used with the combination of PCA.

After comparing datasets with and without PCA various artificial immune classifiers in terms of correctly classified and incorrectly classified instances, it can be observed that the application of principal component analysis improves the percentage is properly classified instances and reduces the number of improper classification.

TABLE II:

Algorithms	TP rate	FP rate	Precision	Recall	F-measure	ROC Area	RMSE
CSCA	0.766	0.239	0.766	0.766	0.766	0.764	0.4841
CLONALG	0.723	0.297	0.725	0.723	0.718	0.713	0.5265
AIR1	**0.789**	**0.213**	**0.789**	**0.789**	**0.789**	**0.788**	**0.4596**
AIR2	0.752	0.2	0.753	0.752	0.751	0.746	0.4975
Immunos1	**0.792**	**0.215**	**0.792**	**0.792**	**0.792**	**0.788**	**0.4560**
Immunos2	0.752	0.285	0.788	0.752	0.738	0.734	0.4975
Immunos99	0.762	0.252	0.764	0.762	0.76	0.755	0.4875

EXPERIMENTAL RESULTS OF HEART DISEASE DATASET WITHOUT PCA

TABLE III: EXPERIMENTAL RESULTS OF HEART DISEASE DATASET WITH PCA

Algorithms	TP rate	FP rate	Precision	Recall	F-measure	ROC Area	RMSE
CSCA	**0.799**	**0.213**	**0.8**	**0.799**	0.797	0.793	**0.4667**
CLONALG	**0.756**	**0.246**	**0.757**	**0.756**	0.756	0.755	**0.5202**
AIR1	0.772	0.233	0.772	0.772	0.772	0.77	**0.4523**
AIR2	**0.779**	0.234	**0.78**	**0.779**	0.777	0.773	**0.4806**
Immunos1	**0.799**	0.225	**0.812**	**0.799**	0.794	0.787	**0.4908**
Immunos2	**0.762**	**0.271**	**0.789**	**0.762**	0.752	0.746	0.5745
Immunos99	**0.779**	**0.244**	**0.789**	**0.779**	0.774	0.767	0.5074

TABLE IV: CORRECTLY AND INCORRECTLY CLASSIFIED INSTANCES OF HEART DISEASE DATASET WITHOUT PCA

Algorithms	Correctly classified	Incorrectly classified
CSCA	**79.86**	**20.14**
CLONALG	**75.57**	**24.43**
AIR1	77.22	22.78
AIR2	**77.88**	**22.12**
Immunos1	**79.86**	**20.14**
Immunos2	**76.23**	**23.77**
Immunos99	**77.88**	**22.12**

TABLE V: CORRECTLY AND INCORRECTLY CLASSIFIED INSTANCES OF HEART DISEASE DATASET WITH PCA

Algorithms	Correctly classified	Incorrectly classified
CSCA	76.56	23.44
CLONALG	72.27	27.73
AIR1	78.87	21.13
AIR2	75.24	24.76
Immunos1	79.2	20.8
Immunos2	75.24	24.76
Immunos99	76.23	23.77

Below Fig. 1 shows a comparison of True positive Rate of various classifiers on the Heart disease dataset. It can be noticed that a large number of AIS classifier performs well with PCA and Fig. 2 reflects a decrease in a false positive rates of most of the AIS classifiers with PCA.

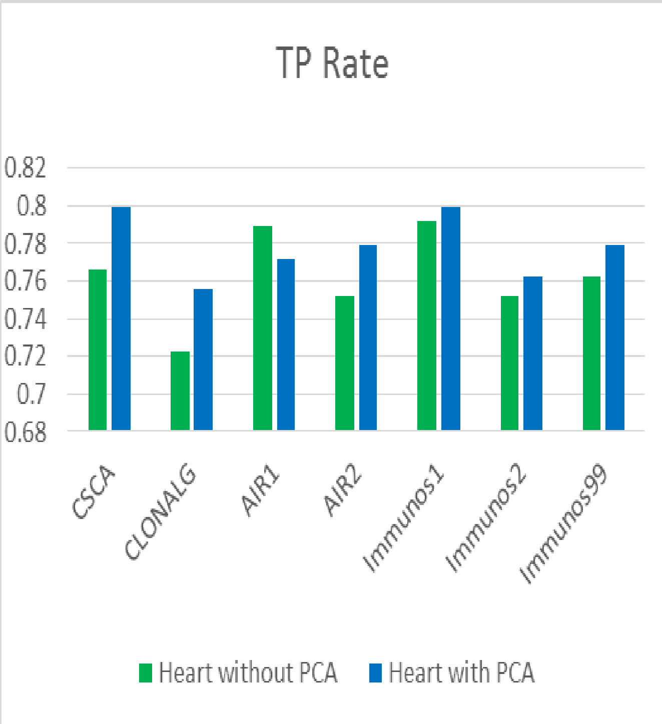

Figure 1: True Positive Rate of classifiers on Heart disease dataset.

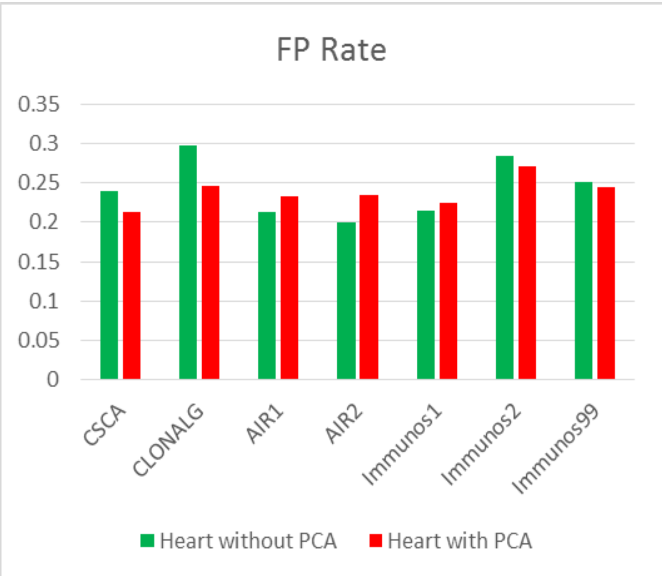

Figure 2: False Positive Rate of classifiers on Heart disease dataset.

The resultant accuracy of the AIS based algorithms with and without the combination of PCA is reflected in the column chart in Fig. 3. It can be clearly observed that, all algorithms CSCA, CLONALG, AIR2, Immunos1, Immunos2, and Immunos99 show improvement in accuracy except algorithm AIRS1 for the dataset.

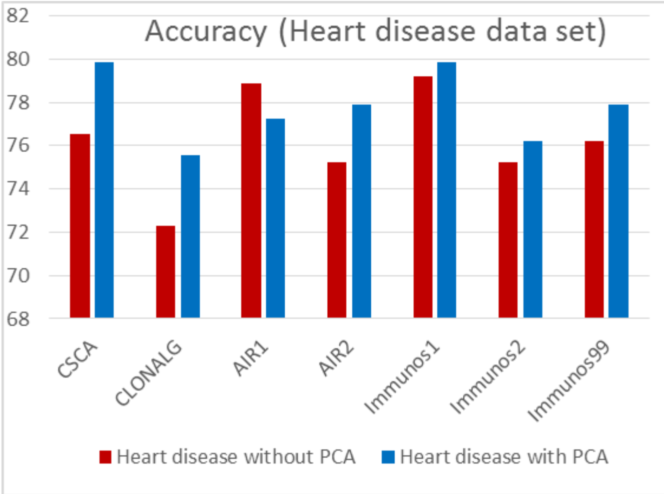

Figure 3: Accuracy of AIS based classifiers with and without PCA.

V. CONCLUSION

This proposed methodology represents the analysis of artificial immune stimulated algorithms toward evaluation of performance, after implementation of principal component analysis (PCA) on the heart disease dataset. Data preprocessing is done by applying normalization and principal component analysis filters on the dataset, afterwards classification algorithms, like CSCA, CLONALG, AIRS1, AIRS2, Immunos1, Immunos2, and Immunos99 are trained and tested for performance with both dataset formats i.e. without PCA and with the combination of PCA. The experimental outcomes, denotes that classification Accuracy, True Positive Rate, and Recall value of the algorithms are increased in the case of most of the algorithms except AIRS1 for this dataset. Algorithms like CSCA, CLONALG, Immunos2, and Immunos99 also displays a less false positive rate after the application of PCA on the dataset. In general, we can state that in some datasets application of principal component analysis filter shows improvement in the performance of the classifiers and accuracy of the algorithms can be achieved up to 80%. Future work can be extended with various datasets and several combinations of filters can be applied to observe the performance of the various reputed classifiers.

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