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Application of Artificial Immune System Algorithms in Dataset Classification

M.Revathi*
Research Scholar,
Karpagam University,Coimbatore

K.Arthi
RVS college of Computer Application,
Coimbatore,Tamilnadu

Abstract— In recent years there is a huge increase in emphasis of interest in studying biologically inspired systems. Artificial immune systems (AIS) are a class of computationally intelligent systems inspired by the principles and processes of the vertebrate immune system. Computer engineers, mathematicians, philosophers and other researchers are particularly interested in the capabilities of this system, whose complexity is comparable to that of the human brain. AIS algorithms are machine-learning algorithms that typically exploit the immune system's characteristics of learning and memory to solve complex problem. It attempts to take advantages and benefits of natural immune systems for use in tackling complex problem domains. It is a class of adaptive or learning computer algorithm inspired by function of the biological immune system, designed for and applied to difficult problems such as intrusion detection, data clustering, and classification and search problems. In this paper, a study of artificial immune systems algorithms like Artificial Immune system Recognition system algorithm (AIRS) , parallel AIRS and clon ALG are presented with the possible number of applications in various domain.

Keywords— AIS, AIRS, Parallel AIRS, ClonALG and classification

I. Introduction

AIS has proven to be capable of performing several tasks, like pattern recognition, learning, memory acquisition, generation of diversity, noise tolerance, generalization, distributed detection and optimization. AIS research began in the mid-1980s with Farmer, Packard, and Perelson’s study[12]. Their study suggested that computer science can might borrow from the immune system. AIS are nonlinear models, and hence are flexible in modeling complex real word relationships. They inherit the memory property of human immune system and can recognize the same or similar antigen quickly at different times.AIS has strong capabilities of pattern recognition, learning and associative memory, hence it is natural to view AIS as a powerful information processing and problem-solving paradigm in both the scientific and engineering fields. Artificial Immune Systems (AIS) possess nonlinear classification properties along with the biological properties such as positive and negative selection, clonal selection, and immune memory. Therefore, AIS, like genetic algorithms and neural nets, is an intelligent tool for applications in various domains.

II. Artificial Immune System

An artificial immune system is a class of adaptive or learning computer algorithm inspired by function of the biological immune system, designed for and applied to difficult problems such as intrusion detection, data clustering, classification and search problems[8]. Various properties of the immune system like uniqueness, recognition of foreigners, anomaly detection, distributed detection; noise tolerance, reinforcement learning and memory are of great interest for computer science researchers to explore in the research areas like clustering, pattern recognition, classification, optimization, and other similar machine learning problem domains[6]. Artificial Immune Recognition System algorithm(AIRS) is a biologically inspired computing paradigm designed specifically and applied to classification problems. The AIRS algorithm exhibits the desirable algorithmic characteristics like self-regulation, performance, generalization and parameter stability[10][14].

A. *Parameters used in AIRS*

AIRS algorithm has a number of user configurable parameters for fine-tuning the training schedule to specific problem domains[15].

- *Affinity Threshold Scalar (ATS):* the mean affinity between a set of antigens from the training dataset. The affinity threshold scalar provides a means of adjusting the automatic threshold by making it softer (less than the mean) or harder (more than the mean). The effect of softening the threshold causes less replacement of best matching memory cells by candidate memory cells, and the reverse is true when the threshold is hardened.
- *Clonal Rate:* Firstly, it is used in conjunction with the hypermutation rate to determine the number of clones that a best matching memory cell can create to population of the ARB pool. Secondly, it is used to determine the number of clones at each ARB which can be created during the ARB refinement stage. Finally, it is multiplied by an ARBs stimulation to determine its resource allocation.
- *Hypermutation Rate:* Used with the clonal rate and cell stimulation, to determine the number of mutated clones a best matching memory cell can create. As mentioned, the number of clones will be in the range of [0,clonalRate] which is then increased by a factor of the hypermutation rate.
- *Total Resources:* The total resources place a direct limit on the number of ARBs that can coexist in the ARB pool which can be 120 or 150.

- *Stimulation Threshold:* The stopping criterion to the ARB refinement process is when the average stimulation value is above the stimulation threshold. This parameter controls the amount of refinement performed on ARBs for an antigen.
- *Number of Initialisation Instances:* Is the number of randomly selected training instances used to seed the memory pool. This parameter can be in the range [0, total training instances].
- *k-Nearest Neighbours:* The kNN parameter is only used during the read-only classification stage of the algorithm. It determines the number of best match memory cells used to vote by majority on the classification of unseen antigens.

B. *Procedure for AIRS algorithm for classification*

- *Initialization:* Dataset is normalized into [0,1] interval. Affinity threshold variable is initialized. Training dataset is normalized to [0,1] range. Memory cell pool and Artificial Recognition Ball (ARB) pool are initialized.
- *Antigen Training:* Each data point in training set is provided to the memory pool to stimulate the recognition cells in memory pool. Stimulation values are assigned to the recognition cells and the cell, which has maximum stimulation value, is marked as the best memory cell. This cell is used for affinity maturation and cloned, then mutated. These clone cells are put into the ARB pool.
- *Competition for limited resource:* After mutated clones are added to the ARB pool, competition starts. Antigen is used to stimulate the ARB pool and limited resource is computed with respect to stimulation values. ARBs with very limited resource or no limited resource are deleted from ARB pool. This step continues until stopping criteria is met. Otherwise, mutated clones of ARBs are produced.
- *Memory cell selection:* Candidate memory cell that has a maximum stimulation score from ARB pool is chosen. ARB is copied to the memory cell pool if ARB's stimulation value is better than the original best matching memory.
- *Classification:* Memory cell pool is used for cross-validation and K-nearest neighbor approach is applied for classification.

C. *Parallel AIRS for classification*

The other interesting area of research for the AIRS algorithm is work into exploiting the parallelism inherent in the techniques base metaphor. Few AlS algorithms exploit the distributed nature and parallel processing attributes exhibited in the mammalian immune system. The approach to parallelizing AIRS was simple, involving the following steps in addition to the standard training scheme:

- Initialize the input and the parameters
- Divide the obtained data set into *np* number of partitions, where *np* is the number of desired processes running AlRS
- Allocate training partitions to processes and prepare memory pools
- Gather the *np* number of memory pools
- Use a merging scheme of affinity between memory cells for creating a master memory pool for classification

D. *ClonALG Algorithm for classification*

The CLONALG algorithm is also a useful AIS algorithm, successfully applied to a number of machine learning and artificial intelligence problems such as binary character recognition, multimodal function optimization and the travelling salesperson problem. De Castro and Von zuben developed the Clonal Selection Algorithm on the basis of clonal selection theory of the immune system. It was proved that it can perform pattern recognition and involves the selection of antibodies (candidate solutions) based on affinity either by matching against an antigen pattern or via evaluation of a pattern by a cost function. Selected antibodies are subjected to cloning proportional to affinity, and hyper mutation of clones inversely proportional to clone affinity[9]. The resultant clonal-set competes with the antibody population for membership in the next generation, and finally low-affinity population members are replaced by randomly generated antibodies. The pattern recognition variation of the algorithm includes a maintenance memory solution set which in its entirety represents a solution[7].

The CLONALG algorithm can be described as follows:

Step 1: Randomly initialize a population of individual (M);

Step2: For each pattern of P, present it to the population M and determine its affinity with each element of the population M;

Step 3:Select n of the best highest affinity elements of M and generate copies of these individuals proportionally.

Step4:Mutate all these copies with a rate proportional to their affinity with the input pattern: the higher the affinity, the smaller the mutation rate;

Step5:Add these mutated individuals to the population M and reselect *m* of these maturated individuals to be kept as memories of the systems;

Step 6: Repeat steps 2 to 5 until a certain criterion is met

III. Applications of Artificial Immune Systems

Artificial Immune Systems is a sub-field of Computational Intelligence motivated by immunology that emerged in the early 1990s.The early works in the field were inspired by immune network theory which was applied to machine learning, control and optimization problems[13]. Early works proposed the immune system as an analogy for information protection systems in the field of computer security[11]. Modern Artificial Immune systems are inspired by one of three sub-fields such as clonal selection, negative selection and immune network algorithms. Chikh et al., used a modified AIRS2 called MAIRS2 where the K- nearest neighbors algorithm is replace with the fuzzy K-nearest neighbors to improve the diagnostic accuracy of diabetes diseases[1]. Kodaz *et al* made a medical application of a new artificial immune system named the information gain based artificial immune recognition system (IG-AIRS) which minimizes the negative effects of taking into account all attributes in calculating Euclidean distance in shape–space representation which is used in many artificial immune systems. This result ensured that IG-AIRS would be helpful in diagnosing thyroid function based on laboratory tests, and would open the way to various ill diagnoses support by using the recent clinical examination data[5].

Shahaboddin et al proposed a new machine learning method of diagnosing tuberculosis which is a combination between fuzzy and a data reduction phase, developed as AIS[2]. Hua Yang et al proposed a framework for the design of AIS based ID Systems (IDSs) to analyze three core aspects such as antibody/antigen encoding, generation algorithm, and evolution mode[3]. Liang et al., proposed a system which applied a combination of two methods of artificial immune and genetic algorithm to diagnose the liver disease. The study represented the immune system's characteristics of learning and memory to solve the problem of liver disease[16]. Arthi et al., proposed an intelligent approach based on artificial immune systems (AIS) to perform the task of classification of autism datasets using fuzzy cognitive maps along with AIRS algorithm. The study focused the use of AIRS and ClonAlg algorithm for the classification of various datasets[15].

IV. CONCLUSIONS

AIS mimic the biological system and intend to solve any complex problem. AIS algorithms can be implemented along with evolutionary algorithm for classification, prediction and for data analysis. This study gives a framework of AIS algorithms and its procedure for any application. Further the desirable properties of the immune system algorithms can be applied in multiple domains along with artificial neural networks and fuzzy concepts.

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