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Abstract

This paper presents a resource limited artificial immune system for data analysis. The work presented here builds upon previous work on artificial immune systems for data analysis. A population control mechanism, inspired by the natural immune system, has been introduced to control population growth and allow termination of the learning algorithm. The new algorithm is presented, along with the immunological metaphors used as inspiration. Results are presented for the Fisher Iris data set, where very successful results are obtained in identifying clusters within the data set. It is argued that this new resource based mechanism is a large step forward in making artificial immune systems a viable contender for effective unsupervised machine learning and allows for not just a one shot learning mechanism, but a continual learning model to be developed.

1   INTRODUCTION

The human immune system has provided inspiration in the fields of computer science and other interdisciplinary problems. The work presented in this paper is concerned with applying immunological metaphors such as the immune network theory [1] to unsupervised machine learning. Previous work has presented an immune network inspired approach to unsupervised learning the Artificial Immune Network (AIN) [2]. Links between cells were created if they were below the Network Affinity Threshold (NAT) which is the average distance between each item in the data set. The initial network was a cross section of the data set to be learnt, the remainder making up the antigen data set. Each member of this set was matched against each B

Cell in the AIN, with the similarity being calculated on Euclidean distance. B Cells were stimulated by this matching process and by connected B Cells in the network. The stimulation level of a B Cell determined the survival of the B Cell, as the weakest 5% of the population were removed at each iteration. Stochastic cloning and mutation were implemented with the number of clones produced dependent on the stimulation level.

In order to assess the performance and behaviour of the evolving system, a variety of AIS properties were recorded and plotted against the number of iterations. This was done for Iris data with the results given in figure 1(a). A number of initial observations were clear: the size of the AIN undergoes exponential population explosion; the NAT eventually becomes so low that only very similar, if not identical clones can ever be connected; the number of B cells removed from the system lags behind the number created to such an extent that the population control mechanism is not effective; the AIN grows so large that it becomes difficult to compute each iteration with respect to time and the resultant networks are so large, they are difficult to interpret, and are large considering the number of data. Figure 2(a) shows the results obtained from the AIS on the Iris data set. The AIS has failed to fully separate three distinct clusters and shows two clusters, one being made up of two further sub-clusters.

2   THE RESOURCE LIMITED ARTIFICIAL IMMUNE SYSTEM

The Resource Limited Artificial Immune System (RLAIS) exhibits behaviour such that once a strong pattern has been identified the network does not deteriorate or lose the pattern. It is proposed that the RLAIS can be used not only for clustering as one shot learning, but also presenting the possibility for the system to perform continual learning. This work in-
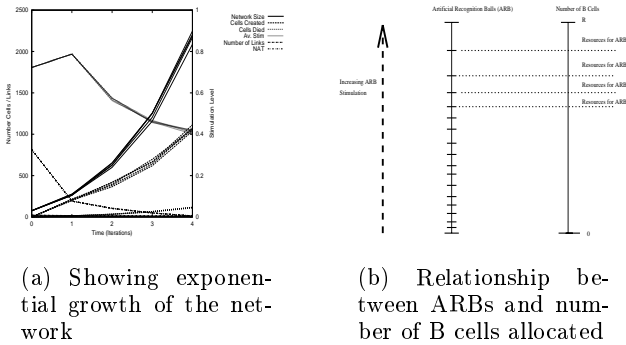
(a) Showing exponential growth of the network

(b) Relationship between ARBs and number of B cells allocated

Figure 1: AIS behavior

(a) Original AIS performance on Iris Data

(b) After 12 iterations of the training data

(c) After 13 iterations of the training data

(d) 314 iterations

Figure 2: Resulting Networks

troduces the concept of an Artificial Recognition Ball (ARB) also inspired by an immunological concept. An ARB is a representation of a number of identical B cells; individual B cells are no longer explicitly represented in the new system. The RLAIS is allowed to contain a pre-defined number of B cells, which the ARBs' must compete for based on their stimulation level. The higher the stimulation level, the more B cells an ARB can claim and, vice versa, see figure 1(b). If an ARB loses all B cells, then it is considered not to be representative of the data being learnt and is removed from the network. This competition for the allocation of B cells stabilises the structure of the network. This stabilising effect can be described as the identification of a strong pattern by the RLAIS and no matter how many time the training data is presented to the RLAIS, that representation will not change. This can be likened to the belief that the immune memory maintains a stable pattern of encounters with past antigens, but is subjected to perturbation in antibody concentration. Additionally, the NAT is no longer recalculated at the end of each training iteration, but is kept constant throughout the learning process. network size was tracked over 600 iterations of the training data. Periods of stable network size were observed and in order to confirm these observations network were visualised. Figure 2 shows the successful identification of three distinct clusters from the Iris data set, that is maintained over time. There are periods when bridges are created between clusters; this is an attempt by the RLAIS to create an increasingly diverse representation of the data. These bridges prove poor matches for the data and do not survive long.

3   Conclusions

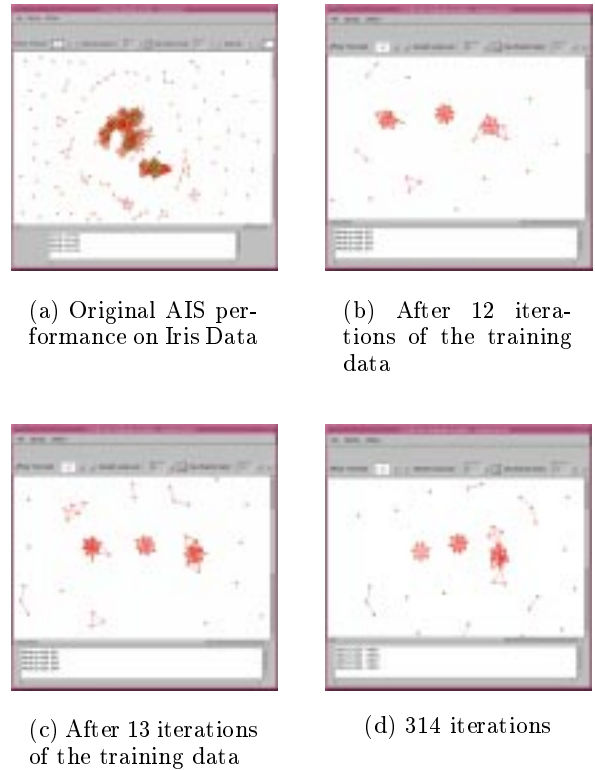This paper has introduced a resource limited Artificial Immune System (RLAIS). Deficiencies in previous work on AIS were identified and solutions provided. The RLAIS introduces the concept of an Artificial Recognition Ball that is representative of a number of B cells. An effective population control mechanism has been introduced that counteracts exponential growth in network size and maintains a stable representation of data being learnt. The size of networks produced by the RLAIS is now suitably restricted allowing effective visualisation while maintaining an accurate and diverse representation of the data compare figure 2(b) with figure 2(a). The RLAIS is effective in classifying unseen data items and is thus useful for data exploration and categorisation. In addition, the RLAIS could be used for continual learning.

References

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