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Chapter 8

Conclusion and Future Work

"It is wise to keep in mind that neither success nor failure is ever final."

- Roger Babson

This chapter concludes the dissertation, discusses the findings and presents ideas relating to possible future work.

8.1 Conclusion

The main objective of this dissertation - to evolve ALCs that have the maximum coverage of non-self space with the least overlap among the ALCs - is addressed. The dissertation started-off with an overview of the functioning of the natural immune system (NIS) - the biological system that protects the body against harmful pathogenic material. The different states of a lymphocyte were also introduced. The dissertation gave an overview of evolutionary computation, focusing on genetic algorithms. A new artificial immune system (namely GAIS) was developed for pattern classification. GAIS uses a genetic algorithm to evolve artificial lymphocytes (ALCs). GAIS evolved the trained ALCs sequentially. Each evolved ALC was added to the set of existing ALCs. The GA was forced with the least overlap restriction to explore different regions in the search space that was not covered by the existing set of ALCs. The evolved ALC was a local optimum in the search space that was not covered by the existing set of ALCs. The ALCs were trained with negative or positive selection to ensure that the ALCs did not detect any of the patterns in the predetermined self set. The active set of evolved ALCs was used to classify patterns. The status of the ALCs was evaluated at predetermined time steps (*IS*) using the life

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counter threshold function proposed in chapter 5, achieving the sub objective, i.e. proposing a method to dynamically determine the status of an ALC. Annihilated ALCs were removed from the active set of ALCs. Results of GAIS on different data sets were presented in chapter 7 and compared with C4.5. These results showed that there are cases that GAIS performs better then C4.5 and that the overlap among self and non-self patterns influences the number of evolved ALCs and the classification performance of GAIS.

8.2 Future work

In most classification models there are always the danger of overfitting the data during training. Thus for future work, an investigation into the overfitting characteristics of GAIS is necessary to determine if the evolved set of ALCs in GAIS and the proposed life counter threshold function alleviate overfitting of data. An investigation to find the optimal operators in the GA could improve the performance of GAIS as well as the replacement of an annihilated ALC with an evolved ALC. As an unsupervised approach, the proposed life counter threshold function might be used in clustering data to indicate the centroids of the formed clusters. It would also be worthwhile to investigate and analyse the parameters in GAIS to be able to dynamically set these parameters for optimal classification performance and to extent the GAIS algorithm for incremental learning. There are a few observations that need to be more closely examined. Firstly, since the evolved optimal initial set is kept static during the training process, the classification performance of GAIS could be improved by replacing the annihilated ALCs with newly evolved ALCs during training. Lastly, to investigate the influence of *IS* on the classification performance of GAIS, since *IS* determines how frequently the status of an ALC is evaluated. A smaller *IS* results in a more frequent removal of annihilated ALCs from the active set of ALCs. Replacing these annihilated ALCs with newly evolved ALCs, could improve the non-self space coverage and thus the classification performance of GAIS. A comparative study between GAIS, existing AIS classification algorithms and machine learning algorithms is currently being conducted by one of the members in the computational intelligence research group (CIRG).