CHAPTER 8

CONCLUSION AND SCOPE FOR FUTURE RESEARCH WORK

8.1 CONCLUSION

The application of hybrid intelligence based search approaches have been examined and demonstrated in the proposed framework to achieve software test optimization. The framework has the advantages of automatic test case generation, identification of optimal test sequences, reduction of number of test cases and minimum number of test runs.

Software test optimization problems are very difficult to solve due to the dynamic nature of the SUT which makes them to be NP-hard. In the proposed framework, three ways of software test optimization are addressed using hybrid intelligence based search approaches. They are:

- Test Sequence Optimization : Using Intelligent Agent (IA)
- Test Case Optimization : Using Hybrid Genetic Algorithm (HGA)
- Test Suite Optimization : Using Artificial Bee Colony (ABC)

The mathematical models for all three optimizations are formulated. In recent years, Intelligent Agents, Hybrid Genetic Algorithm and Artificial Bee Colony have been applied to various hard optimization problems and have emerged as potential techniques to provide solutions with
acceptable accuracy for NP-hard problems. In the light of the above consideration, this thesis proposed Intelligent Agent (IA), Hybrid Genetic Algorithm (HGA) and Artificial Bee Colony (ABC) based search approaches to evolve optimal or near optimal solution for all three types of optimizations and to minimize the testing time and cost.

In the proposed Test Sequence Optimization framework, an Intelligent Agent (IA) namely Intelligent Search Agent (ISA) has been developed. In which, two novel optimization algorithms namely Infeasible Test Sequence Identification and Repeated Subsequence Detection are developed to generate optimal test sequences by identifying infeasible and repeated test sequences in the SUT to reduce the number of test runs. To achieve this, the intelligent search process is guided by two important heuristics namely Happiness Value and Similarity Measure.

In the proposed Test Case Optimization framework, Hybrid Genetic Algorithm (HGA) which combines the features of GA and LS has been applied. The proposed approach produces near global optimal and linear optimal solutions with rapid convergence. The quality of the test cases is improved from generation to generation using mutation score and path coverage based test adequacy criteria. The proposed approach applies two improvement heuristics namely RemoveSharp and LocalOpt to guide the local search procedure.

In the proposed Test Suite Optimization framework, Artificial Bee Colony (ABC) optimization has been applied. The proposed approach applies the working principle of bee colony in searching the SUT. The search is performed by a group of three bees namely Employed, Onlooker and Scout; whose functionalities are extended as Search Agent, Selector Agent and Replace Agent in this research work. During the search process, the improvement heuristic Happiness Value is used as the fitness function to guide the search in covering the SUT.
All the proposed approaches are evaluated by conducting various case studies. The case studies range from simple academic problems to industrial strength software. The performance of each of the proposed optimization approaches are compared with existing approaches.

The performance of the proposed ISA based test sequence optimization approach is compared with ACO (Ant Colony Optimization) based approach. It has been identified that, ISA outperforms ACO in terms of length of the test sequences, cost and time taken by the resultant optimal test sequences of both the approaches and time taken by both the approaches to complete the optimization task.

For HGA based Test Case Optimization, the existing approaches based on Genetic Algorithm (GA) and Bacteriologic Algorithm (BA) are compared to evaluate their performance. It has been concluded that, when compared to these approaches, HGA outperforms in terms of fault revealing and coverage based test adequacy criteria. Also, it consumes only less amount of memory requirement when compared to BA and takes less number of generations when compared to GA without losing the properties of GA.

In the case of ABC based test suite optimization framework, the performance is evaluated by comparing it with GA based test suite optimization. It has been found out that, ABC outperforms GA in terms of time and generations to complete the optimization task. Also, GA often strikes up at local optima, which makes the time taken to be higher; whereas in ABC, since all the three agents are working in parallel, the number of cycles is less and it takes only less time to complete the optimization task. Finally, the test suite contains only effective test cases, which tremendously reduces the testing time in regression testing.
Hence, the proposed framework achieves optimal or near optimal solutions for software test optimization using hybrid intelligence based search approaches.

8.2 SCOPE FOR FUTURE RESEARCH

This research work may be extended for further research in the following dimensions/environments:

- This research work concentrates on optimization based on test adequacy criteria such as coverage and fault revealing capability of the test cases. In the future research work, this can be done based on other test adequacy criteria such as data flow based and LCSAJ based measures.

- For test sequence optimization, a Utility based agent is employed to do the task. As a future work, the other types of agents can be applied to this process and the performance of them can be compared in achieving test sequence optimization.

- In test case optimization, a specific version of HGA has been applied and compared with GA and BA. In the future work, other versions of HGA can be compared to assess the best version to achieve test case optimization.

- In this research work, the performance of ABC is compared with GA for its performance evaluation. As a future work, other versions of ABC could also be tried to identify the best version in achieving test suite optimization.