CHAPTER 8

CONCLUSION AND FUTURE SCOPE

This chapter summarizes the contributions of this thesis, attempts to draw some broad-based conclusions and also indicate some further directions of work. In this research work, an innovative approach has been developed for the design of user defined fractal antennas. This approach includes the implementation of two biologically inspired optimization techniques (BFO and PSO) in conjunction with curve fitting, for making these fractal antennas work at required frequencies. Fractal geometries such as new fractal design, modified Koch curve, and hybrid fractal tree were taken as the candidate structures to check the validity of the developed methodology. All the results have been verified through simulations as well as experimentally by designing laboratory prototype structures.

8.1 Contributions of the Thesis

The important contributions made in the thesis are as under:

(a) Systematic development of a new fractal antenna as per user requirements.

(b) Implementation of asymmetrical ground plane to develop a modified Koch curve fractal antenna for miniaturization and its operation in multi and wideband region.

(c) The developed methodology exploits the advantages of two biologically inspired optimization techniques, viz (i) bacterial foraging optimization and (ii) particle swarm optimization. The motive behind using these optimization techniques are their
inherent simplicity and cooperative knowledge, compared to the competitive mode in the other algorithms.

(d) BFO technique has been first time introduce in fractal antenna community to make these geometries work as per the need of designer.

(e) Development of printed hybrid fractal tree antenna using modified Koch curve for multiband applications and analyze the effect of partial ground plane on the performance of antenna.

(f) Development of hybrid fractal tree antenna using meander line and its performance analysis using different substrates. Investigations on different ground plane area have also been detailed for the proposed design.

(g) The research contributions of this thesis also deal with the design of critical applications of the fractal structures in microstrip antennas where, high precision for the antenna miniaturization and multi/wideband operation is the primary requirement.

8.2 Conclusions

Based on the results of simulation studies and experiments performed in this work, it is concluded that biologically inspired optimization techniques like PSO and BFO in conjunction with curve fitting can be used as an efficient tool for the design of user defined fractal antennas for various wireless telemedicine applications. The comparative evaluation of PSO and BFO performance reveals that although PSO computational time is less, it can be trapped in local minima and may converge prematurely. However, BFO algorithm attempts to make a judicious use of exploration and exploitation abilities of the search space and therefore likely to avoid false and premature convergence in most of the cases. Hence, BFO produce more accurate results than PSO, which is the primary requirement of the presented work. Moreover, with the availability and affordability of high-speed computer systems, the
small difference of the computational time between BFO and PSO can be compromised. The main conclusions are drawn as follows:

(a) A state-of-the-art overview on the use of fractal geometries to the design of microwave components is presented. The antenna performance parameters have been described in detail in the introductory part and it also includes highlights of antenna applications and motivation behind the research work.

(b) The literature review contains conceptual background of different fractal structures including their types and generation procedure. The related literature available on use of biologically inspired computational techniques for fractal antenna has also been reviewed.

(c) The groundwork of the different biologically inspired optimization techniques have been detailed out with special emphasis on BFO and PSO. The main aim of this study is to analyze the basic requirements and strategies concerning the implementation of proposed methodology. The use of optimization techniques are made to overcome the trial and error method of adjusting different design dimensions of the electromagnetic geometry for it to satisfy the designer's need. The discussion also includes the limitations of the conventional design methods and how these limitations can be overcome by using developed approach.

(d) A novel fractal antenna was the first candidate structure of the presented work whose geometrical parameters were determined by using PSO and BFO in conjunction with curve fitting technique. These techniques have been employed to optimize the proposed fractal geometry to get the desired resonant frequency, as there is no direct formula to determine the frequency from the given dimensions of the fractal structure. It was observed that with increase in the iterations, resonant frequency shifts towards lower side that satisfy the space-filling property of fractal antennas, along with
considerable increase in impedance bandwidth. A comparative study illustrated that BFO performs better than PSO in terms of accuracy and antenna performance. IE3D simulator was used to simulate the antenna and its operational frequency was measured experimentally in order to cross validate the performance ability of the used design methodology.

(e) Modified Koch curve fractal geometry has been attempted as second structure for the presented research work described. The theoretical and experimental methodology for the antenna characterization has been explained in detail. When compared with conventional antenna with similar dimensions, modified Koch curve antenna provides additional resonating frequencies without introducing any degradation in the performance of antenna. The asymmetrical ground plane has been optimized by means of BFO and PSO to make the proposed antenna miniaturized and feasible for wide band operation. In this case also BFO beats its competitor PSO in producing accurate results to obtain the antenna design parameters as per user requirements. The outcome of these techniques on radiation pattern are investigated and discussed.

(f) Design and execution of printed hybrid fractal tree structure was presented with the developed methodology. The proposed structure is hybridization of modified Koch curve and fractal tree. An efficient BFO and PSO procedure was applied to obtain the user defined frequencies. With this methodology it was found that the computational time taken by PSO is less but BFO performs excellently to obtain the antenna design parameters that produce noticeable and promising results. The parametric variations of the proposed geometry with varying ground plane width were also discussed. This study shows that by perturbing the ground plane, an excellent impedance matching response is achieved for a certain ground plane size, beyond which the response starts
degrading. The measured electrical parameters confirm the reliability of the antenna and make it feasible for wireless telemedicine applications.

(g) Development of new hybrid fractal tree antenna has been presented as next candidate structure. The proposed geometry has been synthesized by combining two different fractal shapes in a unique hybrid structure and an efficient BFO procedure has been applied to obtain desired resonating frequencies. This work also investigates how the substrate affects the performance of fractal antenna using a numerical approach. Different substrates having different dielectric constants affect the antenna performance in several ways. The substrate properties that are taken into consideration while selecting a dielectric are: dielectric constant, loss tangent and dimensions of the substrate. A clear improvement of the resonating characteristics and patterns of printed antenna on FR4 substrate has been demonstrated. The performance of antenna design and of the corresponding prototype has been assessed through the numerical simulations and experimental measurements.

The presented research work addressed antenna design issues in great detail to understand the fundamental mechanics of these complex antenna systems. By applying the simulation and experimental methodologies presented herein, comprehensive designs incorporating the features that have been discussed have been extensively investigated.

8.3 Future Scope of Work

This work gives rise to many directions that can be explored further. The following aspects may suitably be explored for the future scope of this work to give more insight into the applications of fractal geometries for antenna applications.
(a) The array of the fractal geometries in the ground plane of antennas may be the interesting topic for the researchers. Further the behavior of fractal structures may also be useful for the UWB antenna for notch applications.

(b) Although the design methodology has been developed for fractal structures only, the principle is equally applicable for the design of any radio frequency component. Use of the proposed methodology will give rise to an easy and viable solution for the design.

(c) In order to know the behavior on various parameters, several feeding mechanism in the specific fractal antenna geometry is also an area of future work.

(d) Though the fractal geometries has been studied in a variety of microwave components by the researcher, still there is a scope to investigate the fractal behavior on microstrip filters, amplifiers, combiners etc., for their improved responses.

(e) In order to optimize fractal antenna structure, PSO and BFO approaches have been used. Other metaheuristic approaches like biogeography based optimization approach and firefly algorithm based approach can also be used to optimize the various antenna parameters.