This thesis has presented GSHDC algorithm to mitigate the most complex power system problem i.e. multi-objective Optimal Power Flow (OPF) problem. Two individual objective functions are chosen: 1) minimization of Fuel Cost and 2) minimization of Power Loss. The proposed algorithm is the application of a multi-objective genetic algorithm (MOGA), using the combination of High Density cluster and continuous genetic algorithm. The OPF is modeled as a nonlinear, non-convex and large scale constrained problem with continuous variables. The algorithm uses a local search method for the search of Global optimum solution. Binary coded Genetic algorithm is replaced with continuous genetic algorithm that uses real values of generation instead of binary coded data. An attempt is made to reduce the length.

Chapter 1 presented introduction to the thesis work, giving an overall view of the work carried out.

Chapter 2 presented concepts on heuristic methods like High Density cluster Algorithm, Genetic Algorithm and Particle Swarm Optimisation techniques. It starts with High Density cluster, covering the Basics on Clusters, Cluster Analysis, definitions of core point, border point and noise point and the formation of High Density Cluster. A brief description of Genetic Algorithm, which includes the procedure and important operations like Reproduction, Crossover and
Mutation, is given. Further, an evolutionary computation technique, Particle Swarm optimisation giving the brief coverage on description of basic elements like Particle, Population, Swarm, Position, Particle Velocity, Inertia weight, Individual Best, Global Best and formation of PSO has been given. At the end Primal Dual Interior Point method was explained mentioning important aspects like over view, methodology and salient features. An attempt was made to explain preliminary concepts on High Density Cluster, Genetic Algorithm and Particle Swarm Optimisation which are fundamental methods to carry out this work.

Chapter 3 presented includes various popular techniques in Optimum Power Flow, covering both Conventional as well as Intelligent methodologies. To begin with, the Mathematical representation of optimal power flow problem was described by explaining the objective functions along with non linear equality and non linear inequality constraints. The conventional methods include Gradient method, Newton method, Linear Programming method, Quadratic Programming method and Interior Point method. Among these methods, the Interior Point method (IP) was found to be the most efficient algorithm. The Intelligent methods covered are PSO method and GA method. These methods are suitable in solving multiple objective problems as they are versatile in handling qualitative constraints. Elaborative description and analysis of OPF methods was dealt in this chapter.
Chapter 4 presented a new algorithm for the solution of multi-objective optimal power flow problem. Two individual objective functions were chosen: 1) minimization of Fuel Cost and 2) minimization of Power Loss. The proposed algorithm is the application of a multi-objective genetic algorithm (MOGA), using the combination of High Density cluster and continuous genetic algorithm. The algorithm has used a local search method for the search of Global optimum solution. Binary coded Genetic algorithm was replaced with continuous genetic algorithm that uses real values of generation instead of binary coded data. An attempt was made to reduce the chromosome length and has examined several issues that needed to be taken into consideration when designing genetic algorithm that uses another search method as a local search tool. These issues include the different approaches for employing local search information that is useful for a genetic algorithm searches for global optimum solution. The new technique for the solution of OPF based on Genetic search from a High Density Cluster named in short form as “GSHDC” has been proposed in this thesis. The objective of GSHDC is to retain advantages of Mathematical Programming techniques and to encounter the difficulties of evolutionary methods like GA and PSO Methods. The GSHDC has mainly four stages. **Stage-1:** In the first stage a suboptimal solution for OPF problem is obtained by any of the following local search methods 1) Modified Penalty Factor Method 2) Primal-Dual Interior Point method and
3) Particle Swarm Optimization Method that considers Lagrange multipliers, equality constraints, transmission loss B-Coefficients and penalty factors. Owing to the limitations of the methods, this solution is taken only as **suboptimal or local optimal**. Because of this reason, this OPF solution cannot be taken as a global one. However due to consideration of constraints of control parameters this solution gives a better insight in to the high density cluster. **Stage-2:** Owing to limitations in the local search methods, in the second stage, two independent *High Density Clusters*, which consists of other suboptimal data points in the vicinity of the first are formed by using *Continuous Genetic Algorithm* and DBSCAN algorithm. The active power generation of individual generating units is taken as continuous control variables and the suboptimal solution obtained in the first stage, is first encoded into a chromosome. This chromosome is treated as one of the core points and the Fitness Function (FF) value of this chromosome is calculated and is termed as $E_{ps}$. Then the selection, crossover and mutation processes are carried out for generating new population consisting of other core points (or say other suboptimal solutions), subject to FF values of these chromosomes are within $E_{ps}$. This forms a high density cluster and thoroughly avoids noise points and border points which are regarded as infeasible solutions. It can be stated here that, the length of chromosome in the proposed method is reduced due to non consideration of certain control parameters. This reduces the size of
population of the high density cluster to a greater extent. **Stage-3:** In the third stage, each core point in each high density cluster is ranked using a membership function value. **Stage-4:** In the final stage, a search is carried out for the exact multi objective optimal solution using a Multi Objective Genetic Algorithm (MOGA).

**Chapter 5 presented** implementation of the GSHDC algorithm for IEEE test systems. The standard IEEE 14, 30 and 57 systems were considered to investigate the effectiveness of the proposed methodology. The test was carried with a 1.4-GHz Pentium-IV PC. The GAHDC has been developed by the use of MATLAB version 7. The simulation results were compared with other popular methodologies in a judicious way. GSHDC-IP Algorithm, for OPF problem using suboptimal solution obtained by Interior Point Method was carried out to obtain solution individually for minimum fuel cost and minimum power loss. In addition implementation of MOGA-GSHDC (IP based) Algorithm has been carried out to obtain multi objective solution simultaneously for minimum fuel cost and minimum power loss. Similarly, implementation of GSHDC-PSO Algorithm for OPF problem using suboptimal solution obtained by PSO Method was carried out to obtain solution individually for minimum fuel cost and minimum power loss. In addition implementation of MOGA-GSHDC (PSO based) Algorithm has been carried out to obtain multi objective solution simultaneously for minimum fuel cost and minimum power loss. The implementation of these Algorithms has been done for the well-known
standard IEEE test cases such as 14-bus system, 30-bus system and 57-bus system and simulation results are obtained. From the simulation results, it is observed the results of GSHDC-PSO are superior when compared to the results of GSHDC-IP. Further, results of GSHDC-PSO are compared with the existing methodologies. A typical case study of IEEE 30-Bus system is taken for the performance evaluation of the proposed GSHDC-PSO. The results of GSHDC-PSO method are found better as compared to other existing methods. Further, the results obtained through MOGA-GSHDC (PSO based) are comparable with those of GSHDC-PSO and better than other methods. Losses as well as CPU time using GSHDC-PSO are much improved. Though the single objective (of minimum fuel cost) GSHDC-PSO is giving best minimum fuel cost, but the MOGA-GSHDC (PSO based) is giving a better compromised OPF solution between losses and cost.

**Chapter 6 presented** conclusions and overall view of the work carried out.

**Overall Quantitative/Qualitative Conclusions**

The proposed methodologies could achieve the following objectives there by improved the Genetic Algorithm for OPF solution.
**Quantitative Conclusions**

Result as furnished in Tables 5.8(a), 5.13(a) & 5.40 for 14 Bus system 5.21(a), 5.26(a) & 5.41 for 30 Bus system and 5.31(a), 5.36(a) & 5.42 for 57 Bus system in the new version of the thesis indicate substantial Quantitative improvements as given below:

- Large improvements in Speed.
- Minimum of cost of generation
- Minimum transmission losses
- Good accurate OPF solution.

**Qualitative Conclusions**

The Qualitative improvements derived from the test results as shown in chapter 5, are listed below.

- Avoided the blind search, encountered with infeasible strings, and wastage of computational effort.
- Reduction in population size, number of populations made the computational effort simple and effective.
- In GSHDC method, population is finite in contrast to assume it to be as infinite.
- GSHDC proves a suitable local search method to achieve a right balance between global exploration and local exploration capabilities. These algorithms can produce solutions with high accuracy.
- Demonstrated the improvements in coding and decoding.
- **GSHDC extended to multi-objective OPF problem.** By integrating objective functions, other than cost objective function, it can be
said economical conditions can be studied together with system security constraints and other system requirements.