\chapter\*{ABSTRACT}

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An antenna acts as interface between free space radiations and transmitter or receiver. Yagi-Uda antenna introduced in 1926 by H. Yagi and S. Uda as a directional antenna consisting of a driven element (a dipole or folded dipole) and additional parasitic elements (called reflector and directors). The reflector element is slightly longer than the driven dipole, whereas the directors can be more than one in numbers whose lengths decrease in the direction of radiation. Yagi-Uda antenna is one of the most popular antenna designs in VHF and UHF due to its constructional ease and high gain, typically greater than 10 dB.

Yagi-Uda antenna is, however, difficult to design as physical design parameters such as element lengths, spacings between adjacent elements, and diameter bear complex and non-linear relationships for gain, impedance and Side Lobe Level (SLL), etc. This antenna design problem, further, complicates as the number of antenna elements are increased with the objective

of achieving higher directional gain or number of objectives are increased to meet real world requirements. Therefore, multiobjective optimization of the antenna has always been a catchy problem for researchers. Although, a lot of work is done in this domain, still scope of improvement is visible with modern heuristic of Artificial Intelligence (AI). Gain of the antenna can be optimized by evolving element lengths and spacings between adjacent elements using recent EAs.

This thesis is intended to propose Nondominated Sorting Biogeography Based Optimization (NSBBO) and investigate for multiobjective optimization of six element Yagi-Uda antenna designs to optimize two objectives, viz., gain and impedance, simultaneously. However, designing a Yagi-Uda antenna involves determination of wire lengths and spacings is highly complex and non-linear problem. If gain is intended to increase than imaginary part in impedance becomes significantly large. The convergence performance of different variants of BBO algorithm reported, till date, are also investigated in this thesis, using Nondomianted Sorting (NS) approach for multiobjective optimization of Yagi-Uda antenna design parameters. NSPSO and its different algorithmic variants are also explored for fair comparitive study.

BBO is one of the recently introduced population based stochastic optimization technique inspired from the science of biogeography, i.e., the study of distribution of biological species, over space and time. Similar to many other Evolutionary Algorithms (EAs), to evolve optimal solution to any problem, BBO involves two inherent activities, i.e., (a) the \textit{exploitation} of available solution features (species) is made to happen using process of migration among various potential solutions (habitats), (b) the \textit{exploration} of new solution features occur due to mutation operator. As BBO has shown impressive performance over other EAs in the past research, therefore, is proposed for the concept of multiobjective optimization problem.

PSO is another population based EA that initiates the flight patterns of bird flocks, which was mainly governed by three major concerns: \emph{collision avoidance, velocity matching and flock centering}. The reasons presented for flocking behavior of birds observed in nature are: \emph{protection} from predator and \emph{gaining-food} from a large effective search-space. PSO uses a population of potential solutions called particles that are flown through the search-space with adaptable velocities that determines their movements. Each particle has memory and, therefore, it is capable of remembering the best position, in the search-space, ever visited by it. The position corresponding to the best fitness is known as \emph{pbest} and the overall best out of all particles in the population is called global best or \emph{gbest}.

Since the introduction of BBO, in 2008, various BBO variants are reported by many researchers intended towards improved convergence performance. Three BBO variants, viz., (a) Blended migration, (b) Immigration refusal and (c) Enhanced Biogeography-Based Optimization (EBBO), one most popular ones due to their comparitive performances. Similarly, most popular variants of PSO involves (a) Gloabl Best (\textit{gbest}) PSO, (b) Local Best(\textit{lbest}) PSO, (c) Hybrid Best (\textit{hbest}) PSO or HPSO. Atmost variants have been experimented to simultaneously optimize gain and impedance of six-wire Yagi-Uda antenna design for multiple times in this thesis.

During simulations, the antenna designs are evolved 10 times for gain-impedance optimization with nondominated sorting. Averages of all 10 monte-carlo evolutionary runs are presented for fair convergence investigation of stochastic natured NSBBO and NSPSO algorithms. C++ programming platform is used for coding of NSBBO and NSPSO algorithms, whereas, Method of Moments (MoM) based freeware NEC2 is used for evaluation of antenna designs for gain and impedance. Convergence performance of NSBBO and NSPSO during gain and impedance optimization of Yagi-Uda antenna with all migration variants Maximum gain of Yagi-Uda antenna achieved during optimization using NSBBO and variants is $12.70 dB$ at $50\Omega$ resistive antenna impedance that is better than that of reported in [Singh et al., 2010], i.e., 12.69 dB.

This thesis is outlined as follow: Chapter~\ref{Chapter:1} is devoted to introduction to M.Tech. thesis that includes introduction to research topic, motivation, methodologies, contributions, research findings and organization of thesis. State-of-the-art study of the historical research in optimizing Yagi-Uda antenna using AI and non-AI techniques is represented in Chapter~\ref{Chapter:2}. Chapter~\ref{Chapter:3}, is devoted to multiobjective problems, and methods used to find solution to these set of problems. Chapter~\ref{Chapter:4} is dedicated to study of biogeography, literature background of BBO, algorithmic flow and BBO variants reported till date. Chapter~\ref{Chapter:5} is dedicated to study of particle swarm optimization, literature background of PSO, algorithmic flow and PSO variants reported till date. In Chapter~\ref{Chapter:6}, various design parameters of Yagi-Uda antenna and radiation pattern are represented to formulate antenna design problem as optimization problem. In Chapter~\ref{Chapter:7} firstly, NEC software introduced to carry on simulation and analysis of electromagnetic behavior of various antenna designs. Secondly, implementations flow of NSBBO and NSPSO in C++ along with NEC2. Simulation results of convergence performance of NSBBO as well as NSPSO algorithm and its variants for maximization of gain and simultaneous minimization of impedance of Yagi-Uda antenna, are represented in Chapter~\ref{Chapter:8}. Lastly, conclusion and future scopes of this research are discussed in Chapter~\ref{Chapter:9}

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