**Genetic Algorithm Optimization Applied to Electromagnetics**

Description of the problem:

The objective functions that arise in electromagnetic optimization problems are often highly nonlinear, stiff, multi-extremal, and nondifferentiable. In addition to this, they are almost always computationally expensive to evaluate. To solve these kinds of problems which involve nondifferentiable functions and discrete search spaces, GA’s can be applied.

Antenna design (in particular, array design) is the most studied application of GA’s in electromagnetics. A plethora of studies have investigated GA-based methods of reducing the sidelobes of an array by thinning, amplitude or phase tapering, or element position perturbations. Closely related to this problem is reducing the scattering of strip arrays by thinning or perturbation. Most of these studies involve digital parameters and, thus, are textbook cases for binary or other finite alphabet GA’s. In the given problem, antennas are considered as series or parallel combinations of simple RLC circuits, and the value of these parameters (i.e. R, L, and C) is then calculated based on the condition that the gain is to be maximized.

Mathematical formulation:

The wire is to be augmented with a given number of parallel RLC loads whose locations and element values are to be determined by the GA to produce maximum gain over the frequency band of interest.

The different variables involved in the problem are encoded into a chromosome as follows: each chromosome is divided into sections of NRLC bits. The first bit of these sections denotes whether the load is to be connected in series or in parallel. The next Nl bits decide the position of the load out of a given number of locations. The next 3NC bits are for the values of R, L, and C respectively. Each component is given NC bits to store the values of their resistance, inductance, and capacitance respectively.

Mathematically, it is denoted as follows:

Nant = NRLC(3NC + NL + 1)

Implementation Details:

The range of the values of R, L, C is assumed to be 106. And the units of the corresponding components are taken as ohms, mH, and uF which gives the range for the resistance to be 0 to 106, the inductance to be 0.01mH to 10H, and the capacitance to be 0 to 1F. The gain may or may not depend on the location, however, the effect of location is ignored for the present case. A simple objective function is assumed since the actual objective function was far too complex. A randomized population of chromosomes is generated, and a certain number of individuals selected in the mating pool (through roulette selection). A cross-over rate of 0.6 was taken and individuals were mated using 1-point crossover, with the offspring stored in a second mating pool. Finally, a mutation rate of 0.1 was taken and mutation performed to get a final mating pool. This final mating pool was then retaken as the initial mating pool and the entire process was repeated a given number of times. After each iteration, the fittest chromosome was saved, and the fitness of this chromosome was compared with that of the next iteration and so on. Convergence is observed, and a graph is plotted.