A Comparison of Antenna Placement Algorithms

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Differential Evolution

Step 1: Randomly initialize a population

Step 2: Mutation: For each target $x_i^g, i \in \{1,2,3\ldots,NP\}$, a mutant vector is formed for the subsequent generation using:

$$v_i^g = x_{r_1}^g + F \cdot (x_{r_2}^g - x_{r_3}^g),$$

where $F \in [0,2]$ and r_1, r_2, r_3 are mutually different and also $\neq i$

Step 3: Recombination: Formulate a trial vector as:

$$u_i^{g+1} = \begin{cases} v_{ij}^g, & \text{if rand}() \le CR \text{ or } j = rnbr(i) \\ x_{ij}^g, & \text{if rand}() > CR \text{ and } j \neq rnbr(i) \end{cases}$$

Step 4: Selection: Compare trial vector u_i^{g+1} and target vector x_i^g, and select the vector which yields a smaller cost function.

Step 5: Termination check

Particle Swarm Optimization

Step 1: Randomly initialize velocity and position of all particles

Step 2: At each iteration, updated velocity as follows:

$$v_i = wv_i + c_1 R_1 (p_{i,best} - p_i) + c_2 R_2 (g_{best} - p_i),$$

where $p_{i,best}, g_{best}$ are positions with best objective value found so far by particle and entire population respectively, c_1, c_2 are weighting factors, $R_1, R_2 \sim \mathbb{U}(0,1)$, w is parameter cooling

Step 3: Position updating

$$p_i = p_i + v_i$$

Step 4: Memory updating: Update $p_{i,best}$ and g_{best}

Step 5: Termination check

Parameters - GA and ES

Genetic Algorithm

Test Case	Population	Generations	Mutation Prob.	Crossover Prob.	Elitism	Tournament Size
tc1	500	10	0.1	0.6	50	50
tc2	3600	10	0.1	0.6	360	360
tc3	8500	10	0.1	0.6	850	850
tc4	1500	10	0.1	0.6	150	150

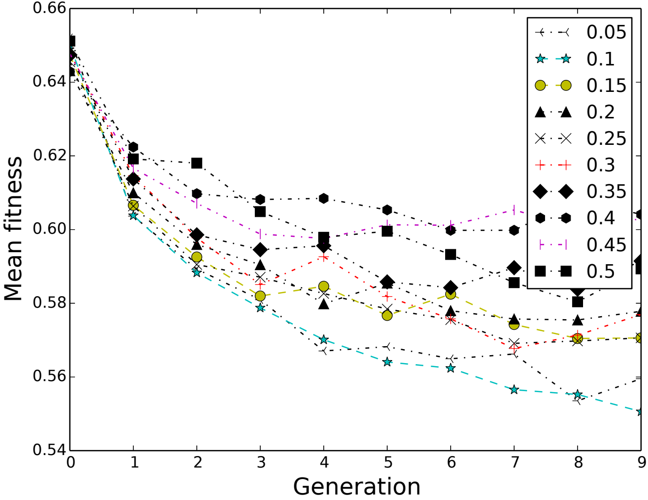
Evolutionary Strategy

Test Case	μ	λ	Generations
tc1	70	490	10
tc2	550	3850	10
tc3	1200	8400	10
tc4	220	1540	10

Parameters - SA

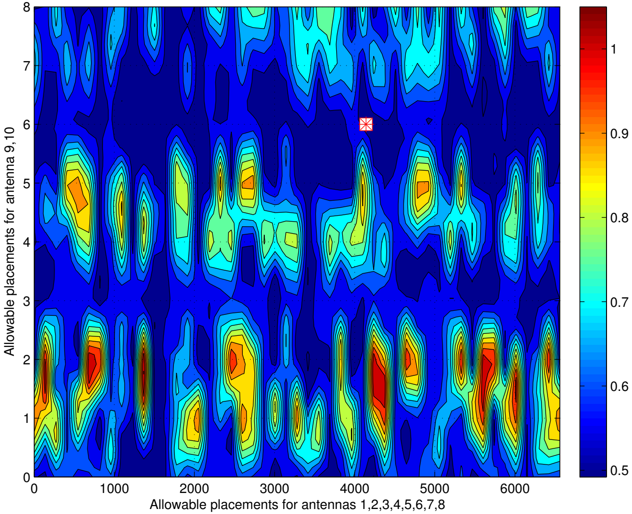
1. Initial Temperature $\in [0.23, 0.27]$
2. Cooling Schedule: Geometric cooling $T_{i+1} = \tau T_i$ $(\alpha < 1)$ where $\tau \in [0.99, 1)$ such that $T_i <= 10^{-4}$ at 50% iterations

Parameter Selection - GA



Parameter Selection - SA (todo)

Search space for larger problem



Search space for problem with 10 antennas resembles contours as seen for experiment test cases

Equivalence of fitness to efficiency

For a particular test case, fitness change of 0.01 is equivalent to either the corresponding value under expected gain ($\mathbb{E}_g$) column, or difference in coupling (Δ_c).

ID	$\mathbb{E}_g$	Δ_c (dB)
tc1	872.277	0.5474
tc2	862.082	1.3034
tc3	861.845	1.5180
tc4	871.049	0.5693

$\mathbb{E}_g = \frac{1}{N \cdot m} \sum_i^m F_{RP}(A_i)$, where $N = |\theta| \cdot |\phi|$