

# A Comparison of Antenna Placement Algorithms

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# Differential Evolution

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Step 1: Randomly initialize a population

Step 2: Mutation: For each target  $x_i^g, i \in \{1, 2, 3, \dots, NP\}$ , 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:

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

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

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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

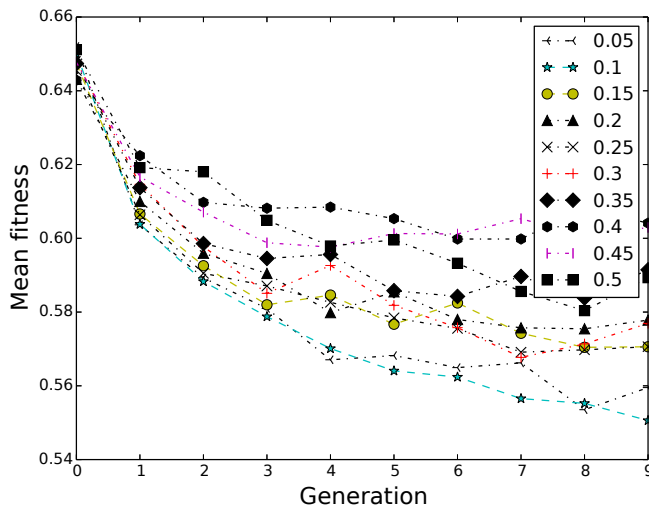
Test Case	$\mu$	$\lambda$	Generations
tc1	70	490	10
tc2	550	3850	10
tc3	1200	8400	10
tc4	220	1540	10

# Parameters - SA

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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  $T_i \leq 10^{-4}$  at 50% iterations

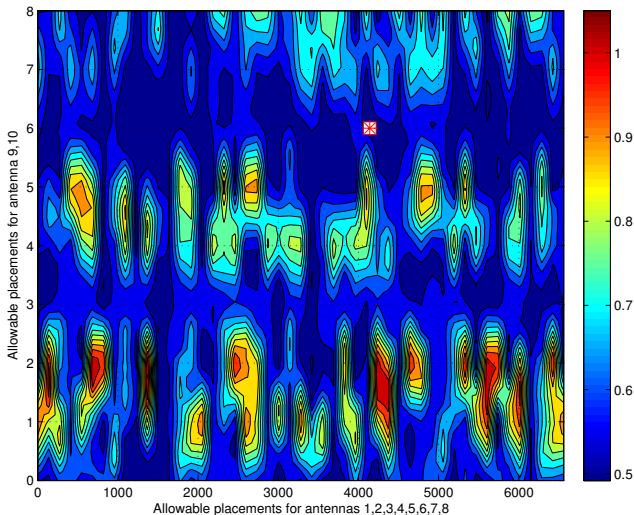
# Parameter Selection - GA



# Parameter Selection - SA (todo)

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# Search space for larger problem



Search space for problem with 10 antennas resembles contours as seen in experiments



# Equivalence of fitness to efficiency

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For a particular test case, fitness change of 0.001 is equivalent to either the corresponding value under expected gain ( $\mathbb{E}\Delta_g$ ) column, or difference in coupling ( $\Delta_c$ ).

ID	$\mathbb{E}\Delta_g$ (dB)	$\Delta_c$ (dB)
tc1	9.34	0.055
tc2	9.28	0.13
tc3	9.28	0.15
tc4	9.33	0.057