A Novel Approach for the Design of Planar Thinned Arrays Based on Genetic Algorithms and Almost Difference Sets

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Abstract

This work presents a novel hybrid procedure that is able to combine the efficiency of analytical almost difference sets (*ADS*s) designs and the effectiveness of genetic algorithm (*GA*)-based search strategies for the design of thinned planar arrays. The proposed approach is able to overcome the current limitations of state-of-the-art analytical thinning methods for planar apertures. Some numerical examples will be shown in order to verify the features and the potentialities of the proposed *ADSGA* design technique.

1 Problem II-a - PSL Minimization in Array Synthesis

In order to determine an optimal thinned configuration starting from the (usually) sub-optimal ADS arrangement with a given aperture size N_{ADS} and thinning factor ν_{ADS}, let us formulate the following constrained optimization problem

$$Min\left(F\{\rho\}\right) = \frac{max_{(u,v)\notin R_m^2}\left\{\left|S(u,v)\right|^2\right\}}{\left|S(0,0)\right|^2}$$

subject to $K = K_{ADS}$ and $N_x \neq N_{x-ADS}$ and $N_y \neq N_{y-ADS}$ ($N > N_{x-ADS}$ and $N_y > N_{y-ADS}$) to be solved through ADSGA.

In such a case, the GA fitness function is defined as the PSL of the array while the constraints force the array to kept its descriptive parameters.

- PSL: Kopilovich
- Initialization: Random vs Hybrid
- Fitness: PSL and Thinning

$$\Psi(i) = \frac{\alpha}{PSL^i_{Kopilovich}} + \beta\nu^i$$

where i is associated to the i-th trial solution.

RESULTS: $P = 10$, $Q = 10$, $K_{ADS} = 25$

Setting Parameters of Algorithms

GA Parameters

- Chromosome Dimension $C = 100\, bits$
- Population Dimension $S = 40$
- Max Iteration number $K_{max} = 5000$

FFT Parameters

- $FFT\ Theta = 128$
- $FFT\ Phi = 128$

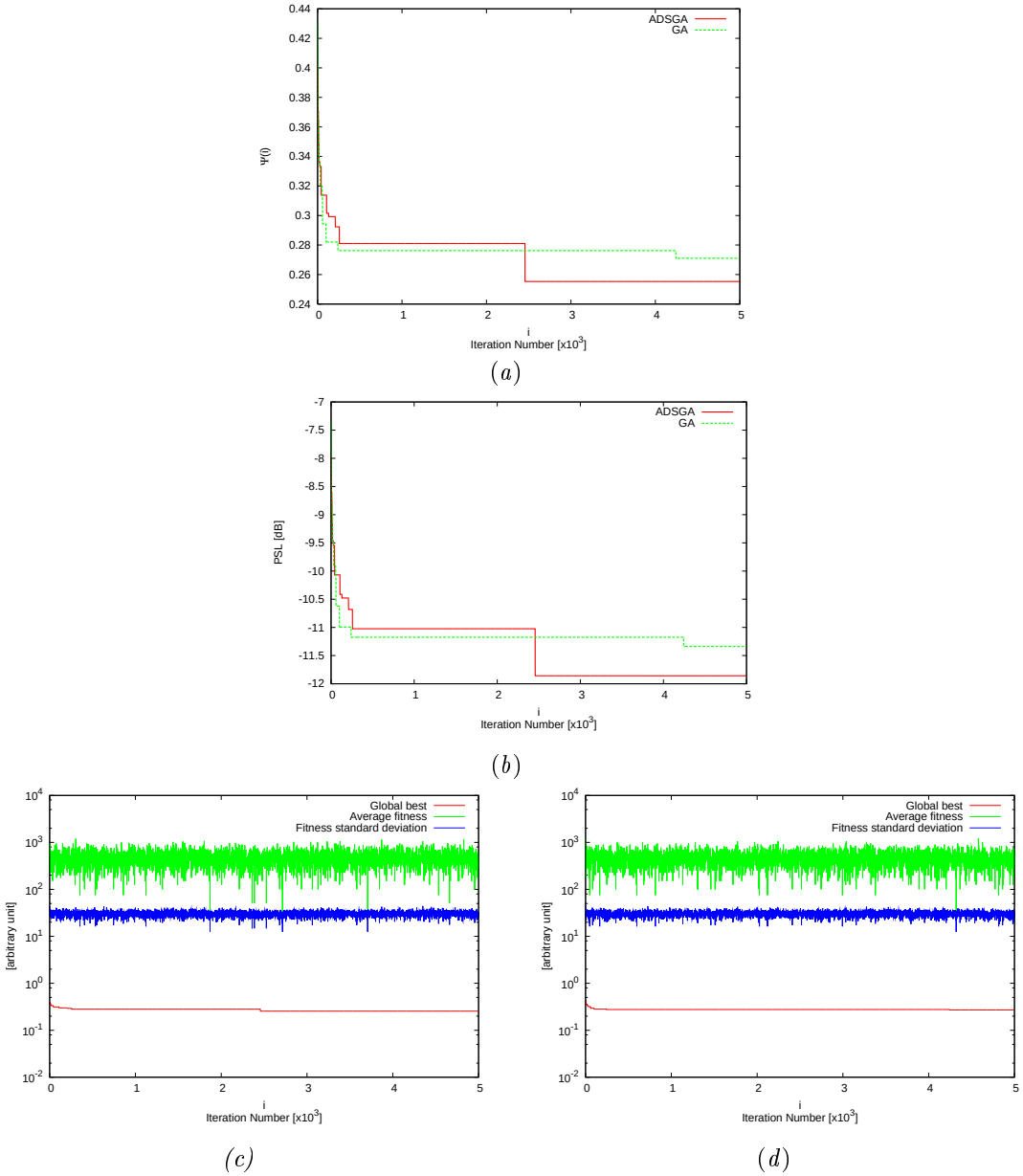


Figure 1.

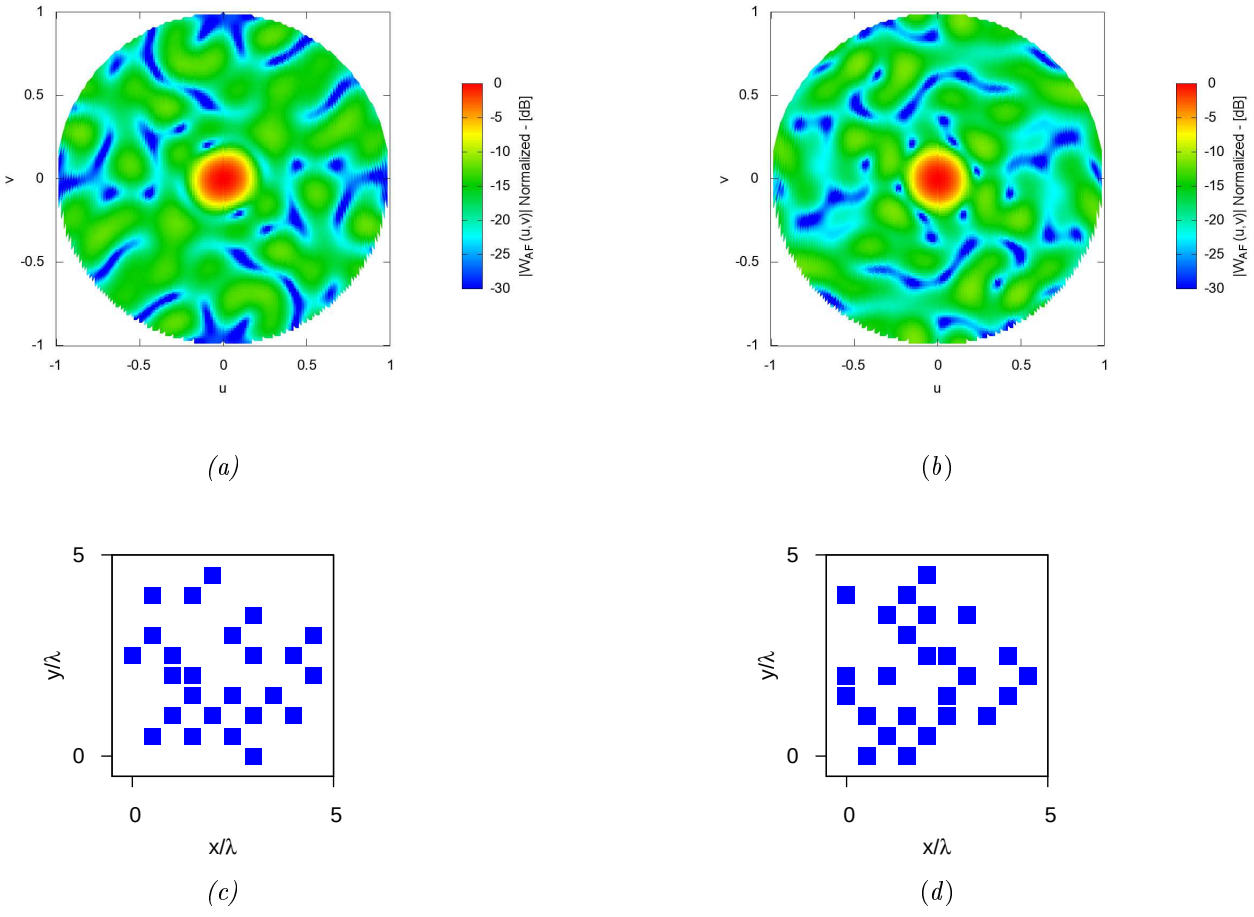
Figure 1: ADSGA approach (c), GA approach (d)

Array Parameters Starting Geometry

- Number of total cells $N = 49$
- Dimension X: 7
- Dimension Y: 7

Array Parameters Final Geometry

- Number of total cells $N = 100$
- Dimension X: 10
- Dimension Y: 10



(a) (b) (c) (d)

Figure 2.

Figure 2: ADSGA approach (*a*)-(*c*), GA approach (*b*)-(*d*)

RESULTS: $P = 16$, $Q = 16$, $K_{ADS} = 85$

Setting Parameters of Algorithms

GA Parameters

- Chromosome Dimension $C = 256\, bits$
- Population Dimension $S = 60$
- Max Iteration number $K_{max} = 5000$

FFT Parameters

- $FFT\ Theta = 256$
- $FFT\ Phi = 256$

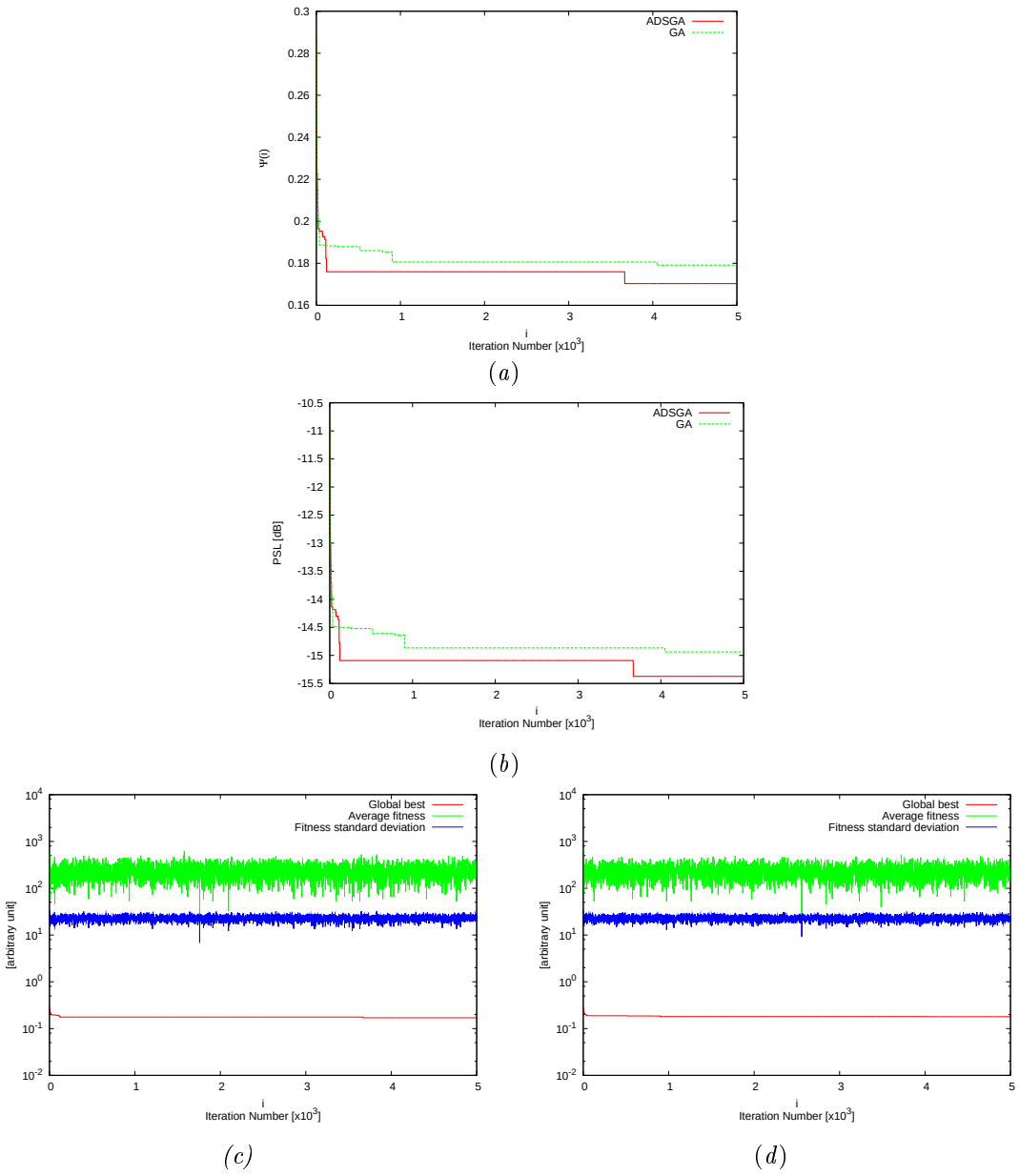


Figure 3.

Figure 3: ADSGA approach (c), GA approach (d)

Array Parameters Starting Geometry

- Number of total cells $N = 169$
- Dimension X: 13
- Dimension Y: 13

Array Parameters Final Geometry

- Number of total cells $N = 256$
- Dimension X: 16
- Dimension Y: 16

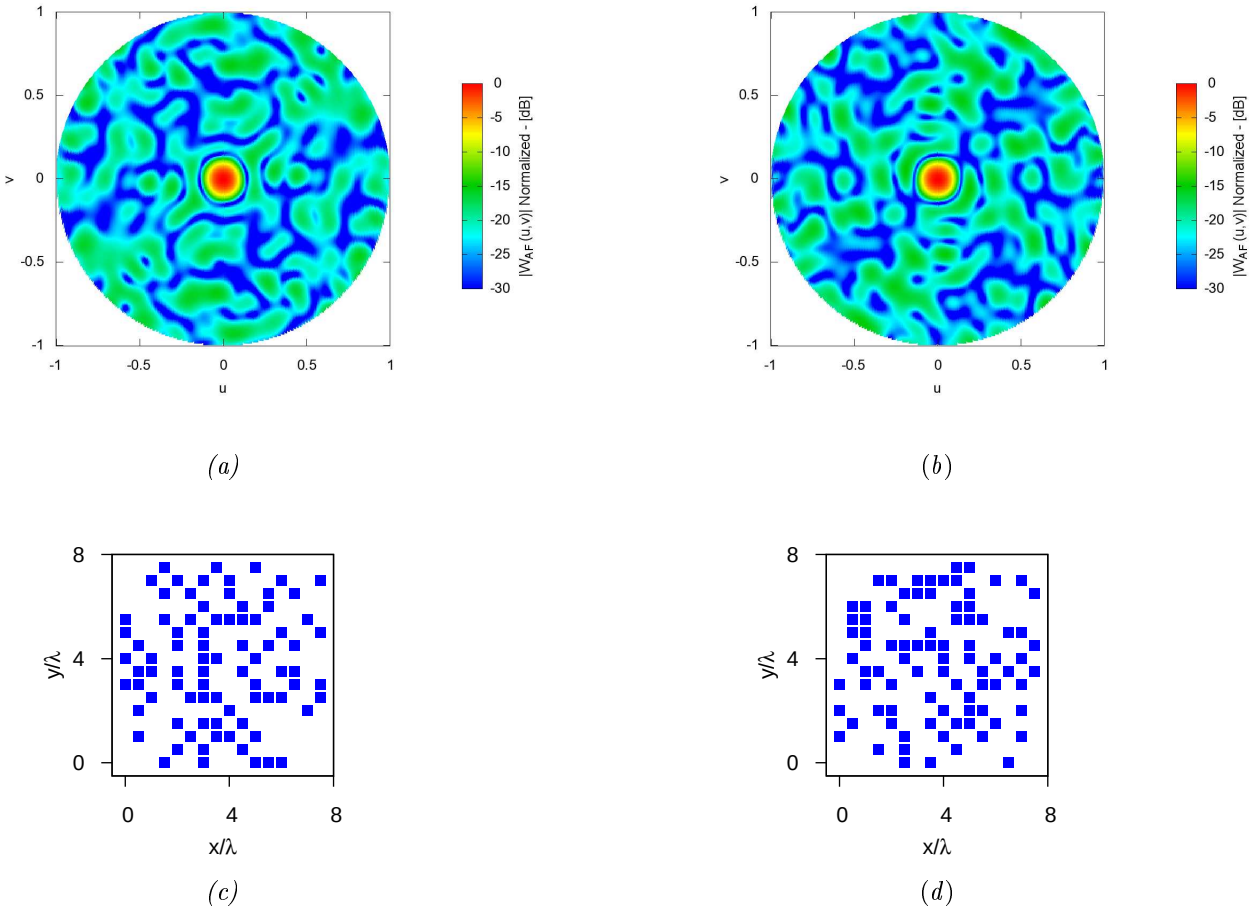


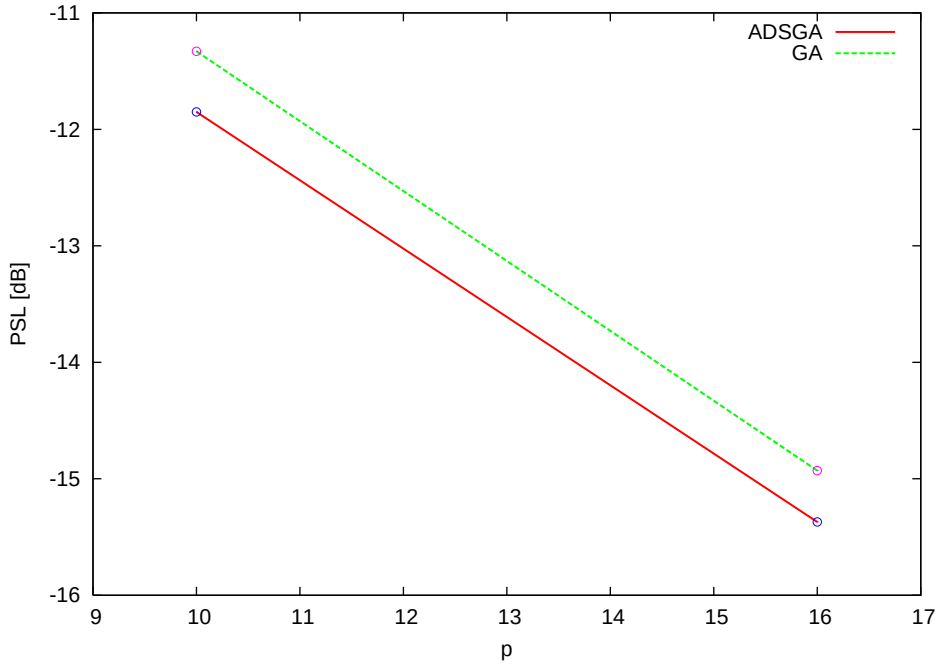
Figure 4.

Figure 4: ADSGA approach (a)-(c), GA approach (b)-(d)

Summary

		$ADSGA$	GA	$ADSGA$	GA	$ADSGA$	GA
$P = Q$		$\nu[\%]$	$\nu[\%]$	$PSL[dB]$	$PSL[dB]$	$BW\ (U_m = V_m)$	$BW\ (U_m = V_m)$
10		0.250	0.250	-11.85	-11.33	0.200	0.200
16		0.332	0.324	-15.37	-14.93	0.125	0.125

Table I



(a)

Figure 5.

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