IRREGULAR ANTENNA CLUSTERING TOOL

2025-11-24

The "Irregular antenna clustering Tool" SW is a designed tool to make the synthesis of Radiation pattern for an array of clustered antennas.

The array can be customized by changing the working frequency, steering angle, the inter-element distance, the number of element of the array, the single element radiation pattern. The single element radiation pattern can be evaluated by the SW (e.g. cosine shape function) or uploaded by EM simulations (e.g. from HFSS SW).

The clustering approach used to group antenna elements can be based on regular or irregular sub-clusters: when more than one type of sub-clusters is selected, we assumed it as irregular clustering, otherwise when only one type of cluster is selected, we assumed it as regular. The type of cluster can be selected by a list of sub-clusters.

The SW return the evaluation of the 3D radiation pattern according to the defined configuration.

1 SOFTWARE STRUCTURE

The SW is collected in the main folder `C: \IRREGULAR_ANTENNA_CLUSTERING_TOOL`

The list of files are:

- `cdf_plot.m`
- `coefficient_evaluation.m`
- `ElementPattern_v2d0.m`
- `EvaluationIncidenceMatrix_v5d0.m`
- `FullSubarraySet_Generation.m`
- `GenerateLattice.m`
- `Generation_code.m`
- `histogram_distrbution.m`
- `Index2Position_cluster_v2d0.m`
- `Kernell_RPE.m`
- `Lattice_Definition.m`
- `LatticeGeneration.m`
- `mask_design_v2d0.m`
- `phase_error_array.m`
- `Post_processing_coefficients_capacity.m`

- PostProcessing_all_steering_angle.m
- PostProcessing_all_steering_angle_table.m
- PostProcessing_multiplesolution.m
- PostProcessing_singlesolution.m
- PostProcessing_singlesolution_failureanalysis.m
- PostProcessing_singlesolution_halfpanel.m
- PostProcessing_singlesolution_modifiedforIHBF.m
- quantization.m
- RotateAlpha.m
- SLL_in_out.m
- SubArraySet_Generation.m

The file RPE_element.csv is an example of the file that can be imported by HFSS.

2 INPUT PARAMETERS

Here are reported the list and the description of the input parameters.

ANTENNA ARRAY PARAMETERS

Parameter	Parameter Explanation	Parameter Type
f	Working frequency	Scalar
Nz	n° of antenna elements on the z axis	Scalar
Ny	n° of antenna elements on the y axis	Scalar
dist_z	distance between antenna elements on y direction (times lambda)	Scalar
dist_y	distance between antenna elements on z direction (times lambda)	Scalar
lattice_type	select the type of lattice. If ==1 is Rectangular grid, if ==2 is Squared grid, if ==3 Triangular Equilateral grid, if ==4 Triangular NON-equilateral Grid, if ==5 Exagonal grid (triangular with alpha=30 deg).	Scalar
azi0	angle for the maximization (minimization) of directivity [deg]	Scalar
ele0	angle for the maximization (minimization) of directivity [deg]	Scalar

Parameter	Parameter Explanation	Parameter Type
azim	half-FoV width azimuthal plane [deg]	Scalar
elem	half-FoV width elevation plane [deg]	Scalar
SLL_level	SLL level outside the FoV [dB]	Scalar
SLLin	SLL level inside the FoV [dB]	Scalar
P	Set P=0 to achieve an isotropic element pattern, set P=1 for cosine element pattern	Boolean
Gel	Maximum antenna Gain [dB]	Scalar
load_file	Set load_file =1 to load antenna element RPE from .csv file, Set load_file=0 to generate isotropic pattern	Boolean
file_name	name of the file with antenna element RPE from .csv file	String

CLUSTER TYPE

	Cluster Orientation	Cluster Size: N° antenna elements
B=[0,0]	no clustering	1
B=[0,0;0,1]	vertical linear cluster	2
B=[0,0;1,0]	horizontal linear cluster	2
B=[0,0;0,1;0,2]	vertical linear cluster	3
B=[0,0;1,0;2,0]	horizontal linear cluster	3
B=[0,0;0,1;0,2;0,3]	vertical linear cluster	4
B=[0,0;1,0;2,0;3,0]	horizontal linear cluster	4

The cluster shape and size can be freely edited by the user, creating a cell with customized parameters.

3 MAIN FUNCTIONS

To run the generation of clustered antenna the users have to use the `Generation_code.m` function. In this code there are many sub-functions that are specified in the following pages. The output of this code is a file (*simulationBF* structure) that collects all possible mapping solution of the regular/irregular clusterization approach.

LATTICE EVALUATION

```
[Y,Z,NN,MM,Dy,Dz,ArrayMask]=GenerateLattice(Ny,Nz,x1,x2)
```

This function generates the basic lattice of grid points parameters according to number of antenna elements and inter-elements distance.

RPE and ARRAY FACTOR

```
[Fel, Fel_VW, RPE, RPE_ele_max]=ElementPattern_v2d0(P,Gel,ELE,AZI,ELEi,AZIi,load_file,rpe_fol
```

This function generates the single element radiation pattern according to selected shape or upload a simulated pattern in .csv file.

The function uploads file with .csv format saved in the SW folder. To generate the RPE file in the propter way please follows the following steps:

1. The antenna element must be placed in the zy plane (we assumed z as vertical axis, y for the horizontal axis);
2. The infinite sphere for the evaluation of the RPE must be defined in the following angular steps:
   - -90¡90 with steps of =0.5deg
   - 0180 with steps of =0.5deg
3. The Far Field Radiation Sphere should be defined according to local coordinate system setted to define the antenna in zy plane;
4. Export the 3D pattern in .csv format.

MAPPING ALGORITHM - Sub-array definition

`[Cluster ,Nsub] = SubArraySet_Generation(B,NN(:),MM(:))`

This function evaluates all possible cluster position according to lattice size and cluster type.

4 POST PROCESSING

The post processing of the generated solution can be performed on different level. Firstly we recommend to have a pre-evaluation of all generated results (*PostProcessing_multiplesolution.m*) in order to identify the best mapping solution. Then, according to the selected mapping we can evaluate the performance (*PostProcessing_singlesolution.m*) by changing the steering angle and changing the SLL mask requirements.

4.1 PRE-EVALUATION OF POSSIBLE SOLUTION

`PostProcessing_multiplesolution.m`

Make a pre-evaluation of all generated results in order to identify in the space of the solution those mapping that match the main requirements:

- No exception of SLL mask outside the FoV
- Minimum Scan Loss in steering condition
- Minimum SLL inside the FoV

4.2 PostProcessing_singlesolution.m

4.3 PostProcessing_singlesolution_failureanalysis.m

4.4 PostProcessing_singlesolution_halfpanel.m

4.5 PostProcessing_singlesolution_modifiedforIHBF.m

4.6 Post_processing_coefficients_capacity.m

4.7 PostProcessing_all_steering_angle.m

4.8 PostProcessing_all_steering_angle_table.m

5 MAIN SW PARAMETERS

Parameter	Parameter Explanation	Parameter Size	Parameter Type
Nel	Total number of antenna elements		Scalar
Ntrans	n° of transceiver chains (clusters)		Scalar
Y	Coordinate of points on y axis	[Nz X Ny]	Matrix
Z	Coordinate of points on z axis	[Nz X Ny]	Matrix
NN	Index of element in y coordinates	[Nz X Ny]	Matrix
MM	Index of element in z coordinates	[Nz X Ny]	Matrix
Lsub	n° of antenna elements for every cluster	[1 X Ntrans]	Vector
Cluster	Index of elements of the i-th cluster	[Ntrans X 2]	Matrix
Yc_m	Y coordinates of cluster's phase center	[1 X Ntrans]	Vector
Zc_m	Z coordinates of cluster's phase center	[1 X Ntrans]	Vector
AZI	Angular scan between -90 and 90 with step of 0.5 deg	[361 X 361]	Matrix
ELE	Angular scan between -90 and 90 with step of 0.5 deg	[361 X 361]	Matrix
Fel	Single element radiation patter [dB]	[361 X 361]	Matrix
Fopt_dB	Normalized radiation patter of clustered array [dB]	[361 X 361]	Matrix