Subarray Optimization (Genetic Algorithm)

That cookbook describes how to select M subarrays with several constraints (AR, MRS, beam elongation, sidelobe level) out of a main array configuration. Note that the representative frequency is 100 GHz.

1 Script execution

- Extract the folder GA_Subarray_Optimization.tar.
- Put in the folder **GA_Subarray_Optimization/GA_Subarray_Selection/Cfg_Input_Files** the main array configuration file in CASA format (e.g. array.cfg).
- Edit the file **GA_Subarray_Optimization/GA_Subarray_Selection/GA_Parameters.txt** for the configuration parameters (input file, plot, etc).
- Edit the file **GA_Subarray_Optimization/GA_Subarray_Selection/GA_Inputs.txt** with the parameters of the subarrays to be optimized and the GA.
- In the folder GA_Subarray_Optimization run the script **Ga_Subarray**. The duration time of the optimization depends on the size of the main array and the size of the subarrays.

2 Results of the optimization

In the folder **GA_Subarray_Optimization/GA_Subarray_Selection/Results**, for each optimization, a folder **Results_x** is created whose name depends on the time **x** with :

- a folder **Subarrays_Storage** with the files ***.cfg** of the subarrays from the array solution in CASA format,
- a file **Final_Constraints_Results.cfg** of the results for the optimization (subarray properties, score, etc),
- a file **GA_Parameters.txt** of the parameters used for the optimization,
- a file **Score_Evolution.png** with the plot of the score of the best solution wrt. the iteration time during the optimization.

3 Subarrays metrics

- Fitness value of an array configuration :

$$Score\_array\_j = -\sum_{i=1}^{M} w_{subarray\_i} \times Score\_subarray\_i$$

  - M : number of subarrays in the main array j,
  - $w_{subarray\_i}$: weight for subarray i (named "Weights_for_Subarrays" in the file **GA_Parameters.txt**, these weights assign importance to each subarray i in comparison to the other subarrays $i' \in [1, M]$),
  - Score_subarray_i : fitness value of subarray i.

- Fitness value of a subarray :

$$\begin{aligned} Score\_subarray\_i =& w_{\theta_{res},i} \times \frac{|\theta_{res\_obj,i} - \theta_{res,i}|}{\theta_{res\_obj,i}} \\ &+ w_{\theta_{MRS},i} \times \frac{|\theta_{MRS\_obj,i} - \theta_{MRS,i}|}{\theta_{MRS\_obj,i}} \times sign(\theta_{MRS\_obj,i} - \theta_{MRS,i}) \\ &+ w_{e,i} \times \frac{|e_{obj,i} - e_i|}{e_{obj,i}} \times sign(e_i - e_{obj,i}) \\ &+ w_{s,i} \times \frac{|s_{obj,i} - s_i|}{s_{obj,i}} \times sign(s_i - s_{obj,i}) \end{aligned}$$

  - $\# : \theta_{res}$ = spatial resolution (arcsec), θ_{MRS} = Maximum Recoverable Scale (arcsec), e = elongation, $s :=$ percentage of the sidelobe level,
  - $w_{\#,i}$: constraint weight (named "Weight_for_#" in the file **GA_Parameters.txt**, these weights assign importance to each property # in comparison to the other properties of the subarray i),
  - $\#_{obj,i}$: objective constraint (objective value for θ_{res}, lower limit for θ_{MRS}, upper limit for e, s),
  - $\#_i$: actual properties of subarray i.

- Score analysis :
  - Fitness value increasing with the iterations (except local minima). The larger value the better score.
  - Fitness value normalized by the subarrays and constraints weights.
  - Fitness value normalized for each constraints.

  The final score should be comparable between different optimizations since the score is relative for each constraint and weighted for the subarrays.