Internship in ESA's Advanced Concepts Team On Graph Partitioning for Multilevel Evolutionary Algorithms

European Space Research and Technology Centre ESA ESTEC

Candidates interested are encouraged to visit the ESA website: www.esa.int/gsp/ACT/

Topic description

Evolutionary algorithms, inspired by biological evolution, are very successful in optimizing problems where the gradient information is not available. One drawback of these methods, in most settings, is their slow convergence on high dimensional problems, such as those often encountered for example in trajectory design or remote sensing tasks. Potential trade-offs in objectives and constraints, as they are encountered in mission design (thermal and radiation protection, energy consumption, size, mass, etc.) further exacerbate the search for good local optima. Multilevel evolutionary algorithms mitigate this by performing evolution on several degrees of coarseness, but require manual definition of the different representations. In multilevel graph partitioning, representations of the different levels are found automatically by considering the connectedness of their elements [1].

The objective of this internship is to understand whether a multilevel graph partitioning approach can be used to speed up evolutionary algorithms in the aerospace engineering domain by keeping highly correlated parameters fixed relative to each other and thus decreasing the effective dimensionality of the problem. The method would be used to find an initial solution to be refined by recovering the original representation for a subsequent local optimization.

Candidate's tasks

- Develop genetic mappings that represent the solution space for space-related design problems.
- Automatically identify correlations between genes in high-performing members of the population.
- Sparsify the correlations to a graph representation.
- Partition the graph to obtain hierarchical representations, this should be done with some existing graph partitioning algorithms.
- Use the hierarchies obtained from the graph partitioning for problem coarsening.

The ideal candidate

Mandatory:

- Strong programming skills in Python and C++.
- Understanding of evolutionary algorithms and graph algorithms.

Desirable:

• Experience in graph partitioning

References

[1] Sanders, Peter, and Christian Schulz. "KaHIP–Karlsruhe High Quality Partitioning." (2019).