Open Internship in the ESA Advanced Concepts Team in 2014

on

# Game Theory for Constrained Optimisation

## Topic Description

Evolutionary game theory has been extensively studied in the field of multi-objective (MO) optimisation: two or more non-cooperative players (represented by sub-populations) evolve in parallel towards improving their personal objective (the two or more competitive objectives of the MO problem), with respect to a subset of variables, until the system reaches an equilibrium [1]. This approach is strictly related to the concept of co-evolution in evolutionary optimisation.

A co-evolutionary constraints handling technique [2], that belongs to the class of penalty methods, has been already implemented in PaGMO. In this approach two populations are evolved sequentially, one encoding the original chromosome and one encoding the penalty parameters. The objective of the internship is to extend the schema of evolutionary game theory for multi-objective optimisation to single objective constrained optimisation (where the number of sub-populations is equal to the number of constraints and each sub-population evolves towards feasibility with respect to a single constraint and optimality with respect to an adaptive penalty fitness formulation of the original objective function) and compare it with the constraints co-evolutionary penalty approach.

Both approaches can be seen as part of the adaptive penalty constraints handling techniques. The main difference between the two are: Nash games populations are evolved in parallel and the encoding of the chromosome is split between different populations, while the co-evolutionary method evolves two populations one after the other as the population encoding the penalties has a fitness function that depends on the first population. Hence the first one follows a concurrent optimisation framework while the second one, a collaborative one, with a different number of sub-populations and a different fitness formulation, both of them with an adaptive penalty schema.

## Candidate's tasks

Implement the constraints technique based on the game theory schema for multi-objective optimisation in the PyGMO/PaGMO framework. Compare it to the co-evolutionary penalty constraints handling technique developed under the GSoC2013.

## The ideal candidate

- Strong programming skills (C++)
- Knowledge about evolutionary optimisation technique
- Knowledge about game theory

## References

[1] Sefrioui M, Periaux J (2000) Nash genetic algorithms: examples and applications. Proceedings of the 2000 Congress on Evolutionary Computation CEC00, IEEE, pp 509-516

[2] Huang, F.Z., Wang, L., He, Q. (2007) An effective co-evolutionary differential evolution for constrained optimization. Applied Mathematics and Computation, 186(1), 340–56.