A Brief Overview of Diversity-Preservation Methodologies in Evolutionary Optimization

Giovanni Squillero
Politecnico di Torino, IT
giovanni.squillero@polito.it

Alberto Tonda
INRA, France
alberto.tonda@grignon.inra.fr

http://www.cad.polito.it/i/cec2014/

ABSTRACT

Divergence of character is a cornerstone of natural evolution. On the contrary, evolutionary optimization processes are plagued by an endemic lack of diversity: all candidate solutions eventually crowd the very same areas in the search space. This situation has different effects on the different search algorithms, but almost all are quite deleterious. Such a "lack of speciation" has been pointed out in the seminal work of Holland in 1975, and nowadays is well known among scholars. The problem is usually labeled with the oxymoron "premature convergence", that is, the tendency of an algorithm to convergence toward a point where it was not supposed to converge to in the first place.

Scientific literature contains several efficient diversity-preservation methodologies that ranged from general techniques to problem-dependent heuristics. The fragmentation of the field and the difference in terminology led to a general dispersion of this important corpus of knowledge in many small, hard-to-track research lines – and the risk of re-discovering equivalent solutions in different communities. The goal of this overview is to re-order and re-interpret different approaches for diversity preservation into a single comprehensive framework, and to define a taxonomy that enables the comparison of techniques originally presented in different evolutionary algorithms.

In the proposed taxonomy, all methodologies are seen as operators able to modify the selection probabilities of existing individuals and are categorized along three main axis: element considered (lineage, genotype, phenotype); type of selection altered (parent, survival); context dependency (dependent, independent). Some effective techniques for altering the selection probabilities will also be discussed. After a brief introduction of the basic concepts, the tutorial will detail the taxonomy with several examples from the literature, spanning all major paradigms of evolutionary computation (e.g., GA, GP, LGP, ES, EP). Notable methodologies will include: Cellular EAs, Deterministic Crowding, Hierarchical Fair Competition, Island models, Segregation, Gender, Restricted Tournament Selection, Sharing, Clearing, Crowded-Comparison Operator, Standard Crowding, and Extinction.