APPLYING STOPPING CRITERIA IN EVOLUTIONARY MULTI-OBJECTIVE OPTIMIZATION

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Most soft-computing, heuristic, non-deterministic or numerical methods have in common that they need a stopping criterion. This criterion, which is usually a heuristic itself, is responsible for minimizing the waste of computational resources by detecting scenarios where it makes no sense to continue executing the method. Hence, the success or failure of any practical application relies heavily on not only the techniques applied but also the support methodologies, including the stopping criterion.

Paradoxically, the matter of stopping criteria and convergence detection has been often overlooked by most of the evolutionary multi-objective optimization (EMO) community. This is probably because it plays a supporting role and, consequently, the theoretical and practical implications concerning this topic have not yet been properly studied and disseminated. However, it can be argued that many real-world applications of theoretically outstanding methods may have underperformed due to an incorrect algorithm termination scheme.

In this tutorial, we propose and updated summary of the results obtained so far in this area and provide re-usable examples of how these methods should be applied in real-life practice.

As already mentioned, the relevance of the stopping criteria issue has been overlooked by the community. Consequently, many real-world applications of theoretically outstanding methods may have underperformed due to an incorrect algorithm termination scheme.

Typically, a stopping criterion is invoked at the end of an iteration of the algorithm. At that point, it is decided whether algorithm execution should continue or can be aborted. We have identified four scenarios when the execution of an algorithm should be terminated:

1. the current solution is satisfactory;
2. the method is able to output a feasible solution, which, although not optimal, is unlikely to be bettered;
3. the method is unable to converge to any solution, or

4. the computation already performed is sufficient to reach a solution or further computation is unjustified.

This tutorial aims to provide the evolutionary computation community a comprehensive reference that encompass:

- a presentation of the theoretical context of the problem with emphasis in the mathematical foundation and, in particular, the Karush-Kuhn-Tucker condition;
- theoretical results regarding convergence in EMO and single-objective evolutionary algorithms;
- characteristics, challenges and requirements of EMO stopping criteria;
- an updated survey of current state of the art on this area, and;
- interactive activity comparing different stopping criteria in order to show their strengths and weaknesses.

By debating and presenting these topics we intend to draw the attention of the EMO community towards this issue as well as to provide usable tools and methodologies to extend the proper use of these methods.

Demonstration and familiarization activities are a fundamental part if the tutorial. In this regard, we will perform a series of "live" comparative experiments relying on the EMO stopping criteria implemented by the authors.

For this purpose, various EMO algorithms will be applied to well-known benchmark problems. The populations of each run of the algorithms will be stored and each of the criteria will be presented with them. This will allow to point out their features and drawbacks. The exercises that will be carried out interactively by the instructors and the interested public will be available on the web during the tutorial and will remain online for later use, reference and study.

The necessary software for tutorial is already available as a MATLAB/Octave EMO stopping criteria taxonomy that contains the "classical" as well as current state of the art methods. This taxonomy is available on-line as open-source software at https://github.com/lmarti/emo-stopping-criteria-taxonomy .