The Effects of Solution Density in the Search Space on Finding Spatially Robust Solutions

Grzegorz Drzadzewski
University of Guelph
Department of Computing and Information Science
University of Guelph, Guelph, Canada
1-519-824-4120
gdrzadze@uoguelph.ca

Mark Wineberg
University of Guelph
Department of Computing and Information Science
University of Guelph, Guelph, Canada
1-519-824-4120 x 54356
wineberg@cis.uoguelph.ca

ABSTRACT
The common definition for robust solutions considers a solution robust if it remains optimal (or near optimal) when the parameters defining the fitness function are perturbed. An alternate definition for robustness where both the solution and the neighbourhood around the solution has high fitness is also in use, which we call spatial or solution robustness. In this paper we examine the effect of the precision of the solution (i.e. density of the search space) on spatial robustness and find that it has a drastic effect on both the number of solutions and their quality.

Categories and Subject Descriptors
G.1.6 Optimization

General Terms
Algorithms, Measurement, Performance, Experimentation

Keywords
Genetic Algorithms, Robust optimization, Representation

1. PAPER
A solution is said to be robust if it is insensitive to variations in the problem, which we call *parameter robustness*. However an alternative definition of robustness refers to a solution that is found in a "high quality" area of the search space, such that perturbations of the solution do not greatly affect the fitness. We call this type of robustness *solution* or *spatial robustness*. Methods that have been used to find robust solutions are very recent [1], many through multi-objective means [2].

In this paper, however, we focused on the design of the search problem as a means of controlling robust solution finding capability of a GA instead of using time-consuming enhancements to the GA. Consequently, all of our experiments were performed on an un-enhanced GA, observing how the GA's natural tendency to find robust solutions changes as the density of the search space changes. The robust quality of solutions found is evaluated by examining the ranking of the best region found and the number of regions identified. The Density of Search Space is directly related to the Chromosome length: the longer the chromosome, the greater the precision of the numeric representation, and hence the larger the density of points in the search space.

GECCO'07, July 7–11, 2007, London, England, United Kingdom
ACM 978-1-59593-697-4/07/0007.

The choice of the density can have a drastic effect on the problem being solved. While the smaller search space is a subgroup of the search space at higher density, changing the density of the search space changes the nature of the search space itself as well as the corresponding solution space of the problem that is being solved. If a certain problem has at two different densities a similar search space, with optima at similar locations, then it is better to search for the solution in the smaller search space – the one with the lower density. A smaller search space can be searched faster as there are fewer points to search.

Furthermore it is possible that the change in the search space can modify the problem such that it becomes easier to find a solution. For example search spaces with lower densities may filter out noise that is present in the function at higher densities. Also location of the points in the search space at lower densities may miss narrow peaks and only leave the wider peaks, which is good for robustness. Of course the new density can be too low and may remove all peaks in the underlying function from the search space. Also changing densities can change the solution space, for example by combining two separate peaks into one.

By examining the standard GA on numerous test functions it is discovered that lower precision representation seems to be able to find better quality peaks (wider) than when higher precision is used. The better peaks found are better on the underlying optimization function, not just within the landscape associated with the different precisions. When lower precision is used, the GA is able to find more peaks within its population, which seems very counter intuitive to us. When a higher precision representation is used, the number of generations it takes for the GA to find acceptable solutions increase. It was also observed that using different sampling of the search space lead to identifying different robust regions in the solutions space.

In conclusion, chromosome length should be set to as low a value as possible without loosing the fundamental structures of the underlying search space.

2. REFERENCES
[1] Jin, Y. and J. Branke, *Evolutionary Optimization in Uncertain Environments - A Survey*. IEEE Transaction on Evolutionary Computation, 2005. **9**(3): p. 303-317.

[2] Deb, K. and H. Gupta. Searching for robust Pareto-Optimal Solutions in Multi-objective optimization. in *Evolutionary Multi-Criterion Optimization*. 2005: Springer-Verlag.