PSO facing ill-conditionned and non-separable problems

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Stochastic optimization algorithms are nowadays widely used to solve real-world optimization problems. In the context of continuous optimization, *i.e.* when the search domain is a subset of $\mathbb{R}^n$, typical real-world problems are ill-conditioned and non-separable. A function is ill-conditioned if the steepness in different directions can change by several orders of magnitude. A function is separable if it can be optimized by sequentially solving the n one-dimensional problems resulting from freezing all but one variable.

This talk presents an experimental evaluation of the performance of the standard PSO 2006 algorithm [2] with respect to non-separability and conditioning. The tests are performed on three classical benchmark functions: (1) a separable convex quadratic function and its rotated, *i.e.* non-separable, version; (2) the non-separable Rosenbrock function; (3) the separable multi-modal Rastrigin function and its rotated version. For the two first functions, tests with different condition numbers have been performed. PSO results are compared to those of CMA-ES [3] that performed best on the test suite defined in [4] for the CEC 2005 special session on parametric optimization [1].

The results show that PSO exploits the separability of the problems: For problem (1), PSO outperforms CMA-ES in the separable ill-conditioned cases, but the situation dramatically reverses on the rotated version. On the (non-separable) Rosenbrock function, the situation is quite similar, in that PSO can only compete at low condition numbers. Finally, on the multi-modal Rastrigin function, both PSO and CMA-ES fail to reach the global minimum when using their default parameter settings. However, increasing the population size improves the performance for CMA-ES to a much greater extent than for PSO on both problem versions, although PSO is found to also exploit the separablity on this highly multi-modal problem.

References

[1] Comparison of evolutionary algorithms on a benchmarck function set. http://www.bionik.tu-berlin.de/user/niko/cec2005.html.

[2] Particle swarm center. http://www.particleswarm.info.

[3] N. Hansen and A. Ostermeier. Completely Derandomized Self-Adaptation in Evolution Strategies. *Evolutionary Computation*, 9(2):159–195, 2001.

[4] P. N. Suganthan, N. Hansen, J. J. Liang, Y.-P. Chen K. Deb, A. Auger, and S. Tiwari. Problem definitions and evaluation criteria for the CEC 2005, special session on real parameter optimization. Technical report, Nanyang Technological University, Singapore AND KanGAL Report #2005005, IT Kanpur, India, May 2005.