

Fractional Multi-Dimensional Particle Swarm Optimization: Algorithms and Applications

Moncef Gabbouj
Department of Signal Processing
Tampere University of Technology
Tampere, Finland
Email: moncef.gabbouj@tut.fi

Abstract

Particle swarm optimization (PSO) was introduced by Kennedy and Eberhart¹ in 1995 as a population based stochastic search and optimization process. The natural behavior of a bird flock when searching for food is simulated through the movements of the individuals (particles or living organisms) in the flock. The goal is to converge to the global optimum of some multi-dimensional function. PSO is conceptually related to other evolutionary algorithms such as Genetic Algorithms, Genetic Programming, Evolution Strategies, and Evolutionary Programming.

In this talk, we present two novel techniques, which extend the basic PSO algorithm. The first algorithm called multi-dimensional PSO (M-D PSO) deals with problems in which the dimension of the solution space is not known a priori (recall that PSO and most evolutionary algorithms assume a fixed dimension). M-D PSO includes two interleaved PSO iteration processes, a positional PSO (equivalent to the basic PSO operation) followed by a dimensional PSO in which the dimension of a particle is allowed to vary. In a multidimensional search space where the optimum dimension is unknown, swarm particles can seek both positional and dimensional optima.

Since the backbone of MD PSO is the basic PSO, it is still susceptible to premature convergence, especially at high dimensions. To address this problem, we propose a second extension of the basic PSO algorithm, called Fractional Global Best Formation (FGBF) technique. Instead of being guided by the best particle in the swarm (the member of the swarm that achieves the best value of the objective so far) a new particle is created whose j 'th component is the best corresponding component of all particles in the whole swarm (i.e. a component-wise best particle). The new particle is essentially a better guide to the swarm than PSO's native global best, since it makes use of the larger diversity existing between the components of the swarm particles. The presented techniques are applied in two well-known domains, nonlinear function minimization and data clustering. An extensive set of experiments shows that in both application domains, MD PSO equipped with FGBF exhibits an impressive speed gain and converges to the global optima at the true dimension regardless of the search space dimension, swarm size and complexity of the problem.

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1. J. Kennedy, R Eberhart., "Particle swarm optimization", in *Proc. of IEEE Int. Conf. On Neural Networks*, vol. 4, pp. 1942–1948, Perth, Australia, 1995.