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Particle Swarm Optimization Containing Cooperative Particles

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1. Introduction

Particle Swarm Optimization (PSO) [1] is a popular optimization technique for the solution of object function and is an algorithm to simulate the movement of flock of birds and the movement of a school of fish toward foods.

In this study, we propose PSO containing cooperative particles (PSOC). The important feature of PSOC is that each particle of PSOC shares the same velocity information. We investigate the behavior of PSOC and confirm its efficiency.

2. PSOC

[PSOC1] (Initialization) Let a generation step $t = 0$. Randomly initialize the particle $i = (1, 2, ..., M)$ position $\boldsymbol{X}_i = (x_{i1}, x_{i2}, ..., x_{iD})$ and its velocity $\boldsymbol{V}_i = (v_{i1}, v_{i2}, ..., v_{iD})$ for all particles i and initialize $\boldsymbol{P}_i = (p_{i1}, p_{i2}, ..., p_{iD})$ with a copy of $\boldsymbol{X}_i$.

[PSOC2] Evaluate the current cost $f(\boldsymbol{X}_i)$. Update the personal best position *pbest* $\boldsymbol{P}_i = (p_{i1}, p_{i2}, ..., p_{iD})$ for each particle i and the global best position *gbest* $\boldsymbol{P}_g = (p_{g_1}, p_{g_2}, ..., p_{g_D})$ among the all particles.

[PSOC3] Update $\boldsymbol{V}_i$ of each particle i depending on its *pbest* and its swarm best *gbest*;

$$\begin{aligned} v_{id}(t+1) = wv_{id} \quad & +c_1 r_1 \{p_{id} - x_{id}(t)\} \\ & +c_2 r_2 \{p_{g_d} - x_{id}(t)\}, \end{aligned} \tag{1}$$

where r_1 and r_2 are two random variables distributed uniformly on $[0, 1]$, w is an inertia weight of all particles, and c_1 and c_2 are positive acceleration coefficients.

[PSOC4] All the particles shared $\boldsymbol{V}_c = (v_{c_1}, v_{c_2}, ..., v_{c_D})$. Let $\boldsymbol{V}_c$ represent the average velocity of all the particles;

$$v_{c_d} = \frac{1}{M} \sum_{i=1}^{M} v_{id} \tag{2}$$

[PSOC5] Update $\boldsymbol{X}_i$ depending on its $\boldsymbol{V}_c$ and $\boldsymbol{V}_i$;

$$x_{id}(t+1) = x_{id}(t) + cv_{c_d}(t+1) + v_{id}(t+1), \tag{3}$$

where c is an cooperation coefficients. In other words, the particles combine the action of individual and cooperation.

[PSOC6] Let $t = t + 1$. Go back to [PSOC2], and repeat until $t = T$.

3. Numerical Experiments

In order to evaluate the efficiency of PSOC and investigate the behavior of PSOC, we compare the two algorithms that PSO and PSOC. PSO is the standard PSO and PSOC is the proposed algorithm. The inertia weight w is 0.5. We carry out the simulation 30 times for two optimization functions with 2000 generations. Figures 1(a), (b), (c) and (d) show the mean *gbest* values of every generation over 30 runs for Sphere function and Rastrigin function with 30-dimension and 100-dimension. The optimum function values $f(\boldsymbol{x}^*)$ of the two functions are 0. From these results, we can confirm that the mean values of PSOC are the best among four problems. Therefore, we can confirm that PSOC algorithm is the most effective.

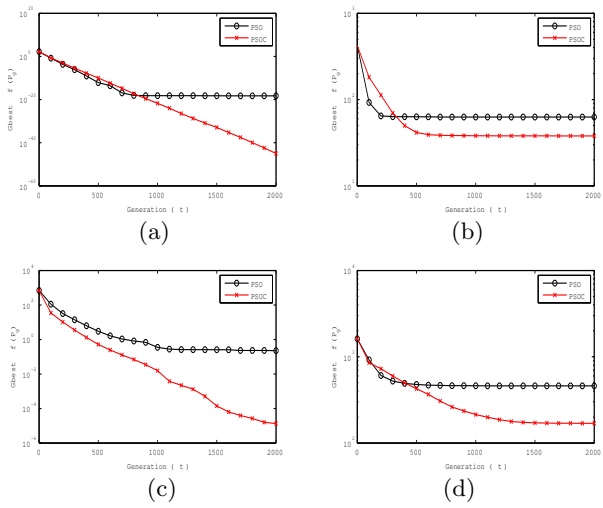

Figure 1: Mean *gbest* value of every generation for four problems. (a) Sphere function (30-dimension,). (b) Rastrigin function (30-dimension). (c) Sphere function (100-dimension). (d) Rastrigin function (100-dimension).

4. Conclusions

In this study, we have proposed PSOC. We have investigated its behavior with the simulation and have confirmed the efficiency.

References

[1] J. Kennedy and R. Eberhart, "Particle swarm optimization", *Proc. IEEE Int. Conf. Neural Netw.*, vol. 4, pp. 1942–1948, 1995.

[2] M. Sugimoto, T. Haraguchi, H. Matsushita and Y. Nishio, "Particle swarm optimization containing plural swarms", *Proc. RISP Int. Workshop on Nonlinear Circuits and Signal Processing*, pp. 419–422, 2009.