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# Particle Swarm Optimization with Two Predators

Norio INUKAI[1]　Takuya INOUE[1]　Yoko UWATE[1]　Yoshifumi NISHIO[1]
([1]Tokushima University)

## 1. Introduction

Particle Swarm Optimization (PSO) is known as one of Swarm Intelligence. PSO algorithm is based on the behavior of fish school, bird flock and so on. It is simple and easily possible to find solutions of optimization problems. However, the standard PSO is hard to get out from local minimum.

Therefore, we have proposed PSO with Predator (PSO-P). PSO-P algorithm is specific fish school (particles) algorithm that is added big fish (predator) by the standard PSO. PSO-P is improved for PSO that particles are eaten by predator.

In this study, we propose PSO with Two Predators. This is added two predators for PSO-P. We compare PSO-P and the standard PSO by using computer simulation.

## 2. PSO-P algorithm

PSO algorithm uses two expression from Eqs. (1), (2).

$$\vec{v}_{k+1} = \vec{a}\otimes\vec{v}_k + \vec{b}_1\otimes\vec{r}_1\otimes(\vec{p}_1-\vec{x}_k) + \vec{b}_2\otimes\vec{r}_2\otimes(\vec{p}_2-\vec{x}_k) \quad (1)$$

$$\vec{x}_{k+1} = \vec{c}\otimes\vec{x}_k + \vec{d}\otimes\vec{v}_{k+1} \quad (2)$$

In this time, expression values are decide.

$$\begin{cases} \vec{v}_k : \text{particle velocity} \\ \vec{x}_k : \text{particle position} \\ \vec{p}_1 : \text{own previous best position} \\ \vec{p}_2 : \text{globally best position in the whole swarm} \\ \vec{a}, \vec{b}_1, \vec{b}_2, \vec{c}, \vec{d} : \text{coefficient} \\ \vec{r}_1, \vec{r}_2 : \text{random numbers} \end{cases}$$

The algorithm of the standard PSO and PSO-P are described below;

**Step 1 { Decide for $\vec{v}_0, \vec{x}_0, \vec{p}_1, \vec{p}_2$ }**

$\vec{v}_0$ and $\vec{x}_0$ decide random number for all particle. $\vec{p}_1$ and $\vec{p}_2$ decide from Eq. (3).

$$\vec{p}_1 = \min\{\vec{x}_k\}, \vec{p}_2 = \min\{\vec{p}_1\} \quad (3)$$

**Step 2 { Update for $\vec{v}_k, \vec{x}_k$ }**

$\vec{v}_k$ and $\vec{x}_k$ are decided update for using Eqs. (1), (2).

**Step 3 { Update for $\vec{p}_1, \vec{p}_2$ }**

$\vec{p}_1$ and $\vec{p}_2$ are decided update for using Eq. (3).

**Step 4 { Predator section }**

Predation decision do for particle around predator. If it is true, we reposition the half of particle that are preyed particle.

In PSO with Two Predators, this step executes twice.

**Step 5 { End decision }**

If $\vec{p}_2$ is smaller than the threshold value, it ends to search solution. Also, if loop count measure up to the threshold value, it ends to search solution.

The standard PSO algorithm repeats Step 2, 3, 5. PSO-P algorithm repeats Step 2–5.

In this study, we fix the parameters as follows; $a = 0.6$, $b_1 = b_2 = 1.7$, $c = d = 1$.

## 3. Numerical Experiments

In order to confirm the performance, we apply PSO and PSO-P algorithm to computer simulation. We use for the optimization of Rosenbrock function Eq. (4).

$$f(x) = \sum_{i=1}^{n-1}(100(x_{i+1} - {x_i}^2)^2 + (x_i - 1)^2 \quad (4)$$

Function dimension is 30. Population sizes is 30 particles. We change the predation radius, 0.1 to 2.0 with 0.1 step size. The predation radius equal 0.0 means the standard PSO. Predator's strategic move patterns are considered 3 kinds (Table 1).

Table 1: Move pattern

| | |
|---|---|
| Pattern 0 | Access optimum point |
| Pattern 1 | Access one time ago optimum point |
| Pattern 2 | Intermediate between 'Pattern 0' and 'Pattern 1' |

The results are shown in Fig. 1. The cost is defined by the following formula Eq. (5).

$$Cost = \frac{Particle\ of\ number \times Average}{Success\ rate} \quad (5)$$

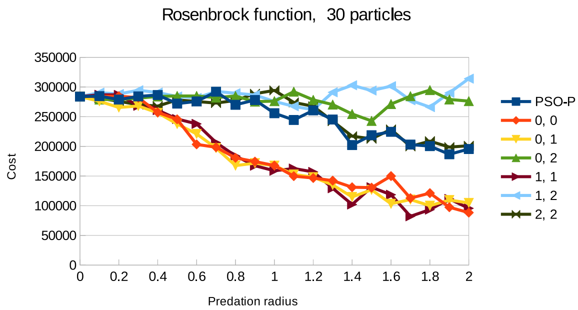


Fig. 1: Rosenbrock results.

PSO with Two Predators is lower cost than the standard PSO. Notably, if predation radius is more, then search solution is low cost. Especially, the results of 'Pattern 2' of predator strategy show the lowest cost.

## 4. Conclusions

In this study, we proposed PSO with Two Predators. We investigated behavior of PSO-P by the simulation and confirmed the efficiency.

In the future work, we would like to adapt other functions in PSO-P.