Function value optimization with PSO

* Problem Description:

The problem purpose is to trying minimize function value by finding global optimum point in the search space.

benchmark functions are described as bellow:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Name | Test Function | S | Global opt. |  |
| **E** | Rosenbrock | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |
| Step | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |
| **M** | Ackley | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |
| Griewank | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |
| **H** | Rastrigin | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |
| Generalized Penalized | C:\Users\somayeh\Desktop\Untitled.png |  |  | 0 |

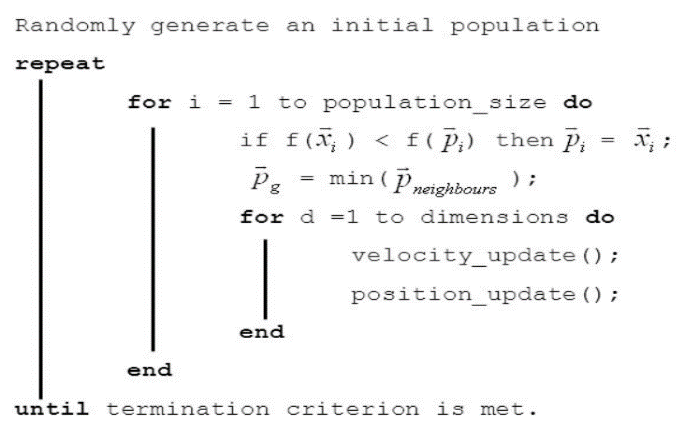
**Description:**

denotes the solution space dimension, denotes a subset of , and the global optimal solution and the global optimal value of classical benchmark functions are given in column 5 and column 6, respectively. Ten independent experiments must be completed for each optimization function considering .

* Algorithm Description:

PSO algorithm is a decentralized Swarm Intelligence search process. The swarm consist of particles with position and velocity related to them. Each particle remembers its best point ever seen as parameter calls “**pbest**”. The whole swarm best reached point remembers as parameter calls “**gbest**”.

The basic concept of PSO lies in accelerating each particle toward its **pbest** and the **gbest** locations, with a random weighted acceleration at each time.



Our PSO algorithm properties come in below:

* + **Initializing:**

Initial particles position set randomly base on problem domain.

initial particles velocity takes positive and negative 10% of particles position as velocity.

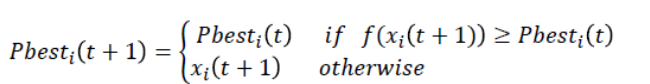
* + **Position & velocity update:**

**

*d* is the dimension, *c1* and *c2* are positive constants, *rand1* and *rand2* are random numbers, and *w* is the inertia weight.

usually *c1+ c2 = 4*. No good reason other than empiricism.

* + **Pbest & Gbest update:**





* + **Inertia weight update:**
    - Large inertia weight facilitates global exploration
    - small on facilitates local exploitation

By decreasing the inertia weight best performance archives.

many research works are conducted where the value is chosen as: w(initial) = 0.9 and decrease to w(final) = 0.2.

We use exponential manner for this purpose as below:

min (math.exp(- 0.9 \* t+1)\*wMax, wMin)

* PSO learning process:
* PSO Results:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Rosenbrock |  |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| *10* | 0/183 | 36/113 | 246/425 | 73/68 | 3/534 | 3/724 | 3/925 |
| *30* | 36/27 | 91264283 | 2/42E+08 | 1/12E+08 | 30/413 | 31/808 | 34/178 |
| *50* | 372345193 | 427387669 | 5/65E+08 | 52384448 | 81/514 | 85/15 | 88/959 |
|  |  |  |  |  |  |  |  |
| Step |  |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| *10* | 0 | 0 | 0 | 0 | 1/532 | 1/764 | 2/091 |
| *30* | 0 | 18830/998 | 73022/25 | 29188/32 | 10/902 | 11/979 | 13/843 |
| *50* | 3/867 | 106877/16 | 129563/6 | 36214/94 | 29/053 | 31/056 | 32/958 |
|  |  |  |  |  |  |  |  |
| Ackley |  |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| *10* | 0 | 0/116 | 1/155 | 0/347 | 3/071 | 3/155 | 3/31 |
| *30* | 1/34 | 9/527 | 20/417 | 7/166 | 22/673 | 25/178 | 29/165 |
| *50* | 18/311 | 20/243 | 20/811 | 0/956 | 60/583 | 64/546 | 68/012 |
|  |  |  |  |  |  |  |  |
| Griewank |  |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| 10 | 0/081 | 0/169 | 0/28 | 0/061 | 3/3 | 4/042 | 4/51 |
| 30 | 0/007 | 228/708 | 630/432 | 282/108 | 25/401 | 26/921 | 30/285 |
| 50 | 948/244 | 1053/5 | 1180/919 | 64/91 | 64/006 | 66/931 | 74/236 |
|  |  |  |  |  |  |  |  |
| Rastrigin |  |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| *10* | 2/985 | 13/432 | 35/818 | 8/304 | 2/977 | 3/093 | 3/652 |
| *30* | 41/87 | 366393/93 | 1840626 | 732424 | 22/784 | 23/651 | 24/491 |
| *50* | 468/99 | 2453097/4 | 3394777 | 1242255 | 62/361 | 65/773 | 70/785 |
|  |  |  |  |  |  |  |  |
| Generalized Penalized | |  |  |  |  |  |  |
| n | **best** | **average** | **worst** | **variance** | **min\_time** | **avg\_time** | **max\_time** |
| *10* | -3/065 | 2273442/9 | 15389408 | 4889766 | 5/798 | 6/182 | 7/254 |
| *30* | -1/022 | 251187239 | 6/7E+08 | 2/62E+08 | 49/613 | 56/328 | 61/644 |
| *50* | 915027566 | 1/044E+09 | 1/25E+09 | 1/02E+08 | 144/241 | 154/673 | 173/673 |

* PSO One-minute run Results:

|  |  |
| --- | --- |
| Rosenbrock |  |
| n | best |
| 10 | 9 |
| 30 | 29 |
| 50 | 49 |
|  |  |
| Step |  |
| n | best |
| 10 | 2/5 |
| 30 | 7/5 |
| 50 | 12/5 |
|  |  |
| Ackley |  |
| n | best |
| 10 | 0 |
| 30 | 0 |
| 50 | 0 |
|  |  |
| Griewank |  |
| n | best |
| 10 | 0 |
| 30 | 0 |
| 50 | 0 |
|  |  |
| Rastrigin |  |
| n | best |
| 10 | 0 |
| 30 | 0 |
| 50 | 0 |
|  |  |
| Generalized Penalized | |
| n | best |
| 10 | -1/142 |
| 30 | 0/405 |
| 50 | 0/714 |

* PSO Algorithm analysis: