Computer Assignment 4  
CPE 261456 (Introduction to Computational Intelligence)

โดย

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เสนอ  
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**ลักษณะการทำงานของระบบ :**

เริ่มต้นด้วยการรับ Input มาโดยจะเป็นไฟล์ excel จะเก็บเฉพาะข้อมูลใน column ที่ 3 6 8 10 11 12 13 14 ไว้เป็นข้อมูลในการ train และ เก็บ column ที่ 5 ไว้เป็น desire output โดยหลักการของโปรแกรมเริ่มจากการกำหนดค่า c1 c2 และ W เสียก่อน โดนปกติ c1+c2 < 4 และ W < 1 โดยหลังจากนั้นกำหนด ขนาดของ iterations และ particles โดยหลังจากนี้จะทำการแยก cross validation โดยแบ่งข้อมูลออกเป็น test 10% และ train 90% โดยหลังจากได้ข้อมูลมาแล้วจะเริ่มกำหนด structure ของ MLP และเริ่มกำหนดของ Search space โดยจะกำหนด ให้มีการสุ่มค่าตำแหน่งของ g\_best และ กำหนดให้ค่า g\_best เริ่มต้นเป็น infinity โดยเมื่อกำหนดค่าเริ่มต้นเสร็จแล้วจะ มาตั้งค่าในส่วนของ Particle โดยแต่ละ Particle นั้นจะถูกสุ่ม position โดย position ในที่นี้ จะนำไปใช้เป็น weight ของ MLP ในขั้นตอนต่อไป โดยจะสุ่มให้อยู่ในช่วงของ -1 ถึง 1 และตั้งค่า p\_best ให้เป๊น infinity โดยทำแบบี้จนครบตามจำนวน Particle หลังจากนั้นจะเริ่มทำการ train โดยจะนำ ค่า Position ของ Particle แต่ละตัวเข้าไปหาค่า fitness โดยจะเป็นการเข้าสู่ model ของ MLP โดย output จะออกมาเป็นค่า และวัดผลโดยการนำ Desire\_output ไปลบกับ ค่าที่ได้ แล้วนำมา absolute บวกกันแล้วหารด้วยจำนวนทั้งหมด โดยถ้าค่า fitness ที่ได้ของ particle นั้นน้อยกว่า p\_best ก็จะกำหนดให้ตำแหน่งนั้นเป็น p\_best และ ค่า fitness ของ p\_best เท่ากันกับ position ของ particle นั้นด้วย โดยจะทำเช่นเดียวกันกับกรณีของ gbest โดยเมื่อทำทั้ง 2 กรณีเสร็จแล้วจะเริ่มทำการเคลื่อนย้าย position โดย จะนำค่า W ก่อนหน้านี้มาคูณกับค่า Velocity ที่กำหนดไว้ให้เป็น ศูนย์ก่อหน้านี้ และนำไปบวกกับ ผลคูณของ c1 กับ ผลลบระหว่าง pbest กับ ค่า position ของ particle นั้น และ c2 กับ ผลลบระหว่าง g\_best กับ ค่า position ของ particle นั้น โดยเมื่อได้ค่า Velocity มาแล้วจะนำค่านั้นไป บวกเพิ่มจาก position เดิม และทำการ update ค่า position และ velocity จากเดิมด้วย ทำแบบนี้ไปจนครบตามจำนวน iterations โดยในผลสุดท้ายจะได้ค่า บอกตำแหน่งที่ทำให้ได้ค่า fitness ที่ดีที่สุด แหละ ตำแหน่ง iteration ที่ดีที่สุดด้วย

**Simulator :**

* **กำหนด Cross validation train 90 % , Test 10%**
* **c1 = 1.2**
* **c2 = 1.4**
* **W = (1/2\*(c1+c2)-1)+0.3**
* **n\_iterations = 10**
* **n\_particles = 10**
* **structure = [8,15,1]**

------------------------- # Round 0 -------------------------

iteration : #1

----> pbest : [17.87372985]

----> pbest : [17.78525689]

----> pbest : [18.28568152]

----> pbest : [18.02354381]

----> pbest : [17.99631829]

----> pbest : [17.71439598]

----> pbest : [17.90514954]

----> pbest : [18.18850479]

----> pbest : [18.41260694]

----> pbest : [17.95330838]

-----> gbest : 17.71439598208045

iteration : #2

----> pbest : [17.71922416]

----> pbest : [17.76584212]

----> pbest : [18.0972294]

----> pbest : [17.6857842]

----> pbest : [17.84975013]

----> pbest : [17.71439598]

----> pbest : [17.85507597]

----> pbest : [17.91081197]

----> pbest : [17.70710475]

----> pbest : [17.91958755]

-----> gbest : 17.685784201468355

iteration : #3

----> pbest : [17.66079267]

----> pbest : [17.76584212]

----> pbest : [17.65235174]

----> pbest : [17.66582928]

----> pbest : [17.6716502]

----> pbest : [17.7022003]

----> pbest : [17.69209105]

----> pbest : [17.73301249]

----> pbest : [17.66452288]

----> pbest : [17.67161174]

-----> gbest : 17.652351741317407

iteration : #4

----> pbest : [17.65704659]

----> pbest : [17.65508232]

----> pbest : [17.65235174]

----> pbest : [17.65555719]

----> pbest : [17.64839764]

----> pbest : [17.6698456]

----> pbest : [17.66870886]

----> pbest : [17.65173047]

----> pbest : [17.64874836]

----> pbest : [17.67117804]

-----> gbest : 17.648397644222946

iteration : #5

----> pbest : [17.64575979]

----> pbest : [17.64587166]

----> pbest : [17.64956693]

----> pbest : [17.64902171]

----> pbest : [17.64473673]

----> pbest : [17.64545855]

----> pbest : [17.64611356]

----> pbest : [17.64624743]

----> pbest : [17.64563356]

----> pbest : [17.6451349]

-----> gbest : 17.644736730637224

iteration : #6

----> pbest : [17.64403443]

----> pbest : [17.64400727]

----> pbest : [17.64956693]

----> pbest : [17.64657364]

----> pbest : [17.64360379]

----> pbest : [17.64255145]

----> pbest : [17.64361413]

----> pbest : [17.64341344]

----> pbest : [17.64563356]

----> pbest : [17.6430403]

-----> gbest : 17.64255145151561

iteration : #7

----> pbest : [17.64316803]

----> pbest : [17.64194799]

----> pbest : [17.64829042]

----> pbest : [17.6434217]

----> pbest : [17.64245646]

----> pbest : [17.64183359]

----> pbest : [17.64260912]

----> pbest : [17.64176144]

----> pbest : [17.64422051]

----> pbest : [17.6430403]

-----> gbest : 17.641761439150297

iteration : #8

----> pbest : [17.64202732]

----> pbest : [17.64140059]

----> pbest : [17.6443326]

----> pbest : [17.6434217]

----> pbest : [17.64245646]

----> pbest : [17.64155795]

----> pbest : [17.64260912]

c:\users\thanakom\_hatsadeang\appdata\local\programs\python\python37\lib\site-packages\ipykernel\_launcher.py:39: RuntimeWarning: overflow encountered in exp

----> pbest : [17.64176144]

----> pbest : [17.64173741]

----> pbest : [17.6430403]

-----> gbest : 17.641400589351786

iteration : #9

----> pbest : [17.64202732]

----> pbest : [17.64140059]

----> pbest : [17.64430148]

----> pbest : [17.6414339]

----> pbest : [17.64181215]

----> pbest : [17.64155795]

----> pbest : [17.64148083]

----> pbest : [17.64176144]

----> pbest : [17.64120651]

----> pbest : [17.64226463]

-----> gbest : 17.641206505120014

iteration : #10

----> pbest : [17.64202732]

----> pbest : [17.64123435]

----> pbest : [17.6410828]

----> pbest : [17.64115859]

----> pbest : [17.64181215]

----> pbest : [17.64124548]

----> pbest : [17.64140727]

----> pbest : [17.64145729]

----> pbest : [17.64106528]

----> pbest : [17.64160773]

-----> gbest : 17.641065275129634

The best solution is: [[-2.63379499 4.41547364 1.09323919 -1.39342584 1.2516736 3.45462124

-3.84950606 2.83257691 1.95573361 3.16776531 -3.40870592 -5.62595074

3.5275277 -1.74886371 -0.06203647 2.82671741 -2.28651437 -1.94030776

-1.55350529 2.02549334 0.42593572 -5.65348397 -2.69590908 0.60129575

4.36172909 -1.97180065 2.90071355 -0.51711266 -1.95431334 2.1454045

0.14745931 -2.0294582 3.77607001 1.98545712 -1.52084159 -3.81550369

-2.99949312 5.1150206 5.22230829 3.36591555 0.3757154 -2.5594551

-3.75391704 2.92170092 5.3218712 1.37628417 -3.40898742 3.77691157

-1.24445348 3.15673897 2.0154715 3.3138115 1.53069582 -2.08443204

2.98291604 -0.01258459 1.55299585 -1.28286416 -1.30921481 -1.04059739

-1.1617546 -4.5801254 -2.44440504 -0.4120206 3.18935471 -6.244058

-3.02414564 1.77243127 -3.00093476 -2.47779402 -2.18408898 -2.5374266

2.41115901 0.9494781 -4.109809 2.96304368 4.39405555 0.26137937

2.27104818 -4.26266937 3.4739103 -3.18925167 -4.6094642 -0.97718225

-1.09066222 -0.7087531 -2.0247777 3.35415823 -1.1522508 5.12185009

3.07065417 -2.23504426 -1.15447182 1.68546217 5.16677018 0.55037713

-1.02871064 -2.61768632 4.23027449 -2.28216193 -0.96425729 -0.28792228

-2.87142473 2.78074684 1.38872991 2.5966237 -0.84255795 4.29812674

-3.40510535 -1.41737691 -1.05317343 -2.45888545 -2.2301019 0.91137502

2.81779071 -2.23597284 -1.91987901 -1.75023219 -4.10245547 2.24535106

1.37449094 2.41245322 -3.11298021 4.86525952 2.32805658 1.49452794

2.27532278 0.79583596 1.03848767 6.41650449 -1.87852061 -3.56082913

-1.23971473 -0.35949699 2.60873132]] in n\_iterations: 10

------------------------- # Round 1 -------------------------

iteration : #1

----> pbest : [18.35199675]

----> pbest : [18.30429306]

----> pbest : [18.14305788]

----> pbest : [17.86680083]

----> pbest : [18.43146923]

----> pbest : [17.81411658]

----> pbest : [18.27198574]

----> pbest : [18.35054127]

----> pbest : [18.38533743]

----> pbest : [18.11466311]

-----> gbest : 17.814116581912558

iteration : #2

----> pbest : [18.2410586]

----> pbest : [18.11442077]

----> pbest : [17.98412747]

----> pbest : [17.80004536]

----> pbest : [17.95945493]

----> pbest : [17.81411658]

----> pbest : [17.8590371]

----> pbest : [18.17710564]

----> pbest : [18.04385001]

----> pbest : [17.9607119]

-----> gbest : 17.800045360635593

iteration : #3

----> pbest : [17.80664032]

----> pbest : [17.87232868]

----> pbest : [17.98412747]

----> pbest : [17.68869128]

----> pbest : [17.81003416]

----> pbest : [17.809062]

----> pbest : [17.85747241]

----> pbest : [17.7364525]

----> pbest : [17.81676895]

----> pbest : [17.87200701]

-----> gbest : 17.68869128440882

iteration : #4

----> pbest : [17.66352223]

----> pbest : [17.74619159]

----> pbest : [17.98412747]

----> pbest : [17.65973817]

----> pbest : [17.65829774]

----> pbest : [17.6695602]

----> pbest : [17.84026533]

----> pbest : [17.65573752]

----> pbest : [17.70009492]

----> pbest : [17.86803684]

-----> gbest : 17.655737523346204

iteration : #5

----> pbest : [17.64670922]

----> pbest : [17.67760134]

----> pbest : [17.67290793]

----> pbest : [17.65296151]

----> pbest : [17.64408031]

----> pbest : [17.6476024]

----> pbest : [17.68878542]

----> pbest : [17.64732568]

----> pbest : [17.6602345]

----> pbest : [17.69576731]

-----> gbest : 17.644080310374452

iteration : #6

----> pbest : [17.64282507]

----> pbest : [17.64274781]

----> pbest : [17.64216164]

----> pbest : [17.64358125]

----> pbest : [17.64217978]

----> pbest : [17.64210101]

----> pbest : [17.64267345]

----> pbest : [17.64379784]

----> pbest : [17.64350644]

----> pbest : [17.65670241]

-----> gbest : 17.64210100663585

iteration : #7

----> pbest : [17.64162179]

----> pbest : [17.6412452]

----> pbest : [17.64118338]

----> pbest : [17.64166928]

----> pbest : [17.64165845]

----> pbest : [17.64132482]

----> pbest : [17.64146483]

----> pbest : [17.64162221]

----> pbest : [17.64142529]

----> pbest : [17.64118173]

-----> gbest : 17.64118173251054

iteration : #8

----> pbest : [17.64142719]

----> pbest : [17.64110487]

----> pbest : [17.64098674]

----> pbest : [17.64109253]

----> pbest : [17.64122496]

----> pbest : [17.64108313]

----> pbest : [17.64146483]

----> pbest : [17.64140796]

----> pbest : [17.64108056]

----> pbest : [17.64101158]

-----> gbest : 17.6409867366102

iteration : #9

----> pbest : [17.64095709]

----> pbest : [17.64102156]

----> pbest : [17.64095872]

----> pbest : [17.64094527]

----> pbest : [17.64092847]

----> pbest : [17.64094711]

----> pbest : [17.64095704]

----> pbest : [17.64100635]

----> pbest : [17.64093484]

----> pbest : [17.6409557]

-----> gbest : 17.64092847178121

iteration : #10

----> pbest : [17.64090504]

----> pbest : [17.64092352]

----> pbest : [17.64094801]

----> pbest : [17.64090667]

----> pbest : [17.64090205]

----> pbest : [17.64090764]

----> pbest : [17.64091388]

----> pbest : [17.64090815]

----> pbest : [17.64091104]

----> pbest : [17.64091611]

-----> gbest : 17.640902048391098

The best solution is: [[ -6.4832832 -6.13795358 5.77562425 -1.81230608 3.43818348

-2.81348287 1.44800808 -0.35487679 -3.75918006 -4.4809281

-8.06711436 2.81589757 5.52988555 3.57274885 -1.30511484

-3.5833661 -8.08235703 -1.01645491 4.7738605 -5.08111708

5.06468466 -8.52123356 -6.42239713 -4.60395169 5.13094222

-3.45237075 -2.57619171 0.62359813 -1.29557636 -0.12002319

-2.71776339 -3.24382329 4.43697651 -5.35547353 0.43479757

-4.08781594 -1.73519392 -4.55096914 -0.14607504 -3.12990028

-1.40230376 1.92986004 -8.78151925 4.98455877 8.0666585

-2.55619555 -3.93934025 9.25332477 -5.71662169 -6.74344745

5.6834302 -1.62213739 1.21263985 -2.62249906 -2.69569074

-10.18657436 -2.7782835 -0.56424775 -6.81244173 1.91524741

-1.2501333 6.5039129 -1.43979866 0.40667867 -7.52327266

4.50953745 2.02390338 2.37657363 -6.60540392 3.29948125

-2.57527844 -3.5686056 1.66312583 5.26412896 6.82569448

2.37815236 -5.44021601 0.9044605 -8.75065334 6.46688993

1.52083226 3.01053112 -6.11685766 1.92894559 -1.99590236

-2.72921994 3.94101445 6.2938213 2.20861301 -9.56718068

-3.31227187 0.02094668 1.45755295 0.05659061 -1.05766387

-0.31582863 -3.97222107 2.63756785 -1.33714712 4.76183094

-2.21958918 0.16048024 0.99339238 -1.94654356 -2.36177409

-4.69580358 -5.29754253 7.35187378 4.12000168 0.86692489

-1.98767515 0.51740554 9.42315433 4.32491494 -7.15205794

6.29424883 0.81006031 -3.54305674 -0.96876022 7.6283188

4.07416055 -0.52127003 7.28197393 2.33909108 -3.75195152

-2.37500505 2.37152793 -0.84229141 1.17273928 -1.51996242

1.55854485 3.25059543 -0.57048417 3.50051605 4.85788501]] in n\_iterations: 10

------------------------- # Round 2 -------------------------

iteration : #1

----> pbest : [18.25225474]

----> pbest : [18.31198194]

----> pbest : [18.01175112]

----> pbest : [17.95237556]

----> pbest : [18.05842628]

----> pbest : [17.67567514]

----> pbest : [18.39995328]

----> pbest : [18.36607755]

----> pbest : [17.95109123]

----> pbest : [17.7778561]

-----> gbest : 17.675675138372295

iteration : #2

----> pbest : [17.66024856]

----> pbest : [17.73165339]

----> pbest : [17.67633262]

----> pbest : [17.74027669]

----> pbest : [17.70427507]

----> pbest : [17.67567514]

----> pbest : [18.39506874]

----> pbest : [18.26141616]

----> pbest : [17.89738557]

----> pbest : [17.6757008]

-----> gbest : 17.660248560080923

iteration : #3

----> pbest : [17.64434123]

----> pbest : [17.6541126]

----> pbest : [17.6445339]

----> pbest : [17.65110414]

----> pbest : [17.64862939]

----> pbest : [17.65958265]

----> pbest : [17.65656304]

----> pbest : [17.69933134]

----> pbest : [17.64708335]

----> pbest : [17.6757008]

-----> gbest : 17.644341232771954

iteration : #4

----> pbest : [17.64232361]

----> pbest : [17.64329963]

----> pbest : [17.64165485]

----> pbest : [17.64314547]

----> pbest : [17.6423806]

----> pbest : [17.64583471]

----> pbest : [17.64174258]

----> pbest : [17.64409519]

----> pbest : [17.6412186]

----> pbest : [17.66905561]

-----> gbest : 17.64121859927813

iteration : #5

----> pbest : [17.64232361]

----> pbest : [17.64105313]

----> pbest : [17.64115667]

----> pbest : [17.64103376]

----> pbest : [17.6423806]

----> pbest : [17.6410047]

----> pbest : [17.6414395]

----> pbest : [17.64409519]

----> pbest : [17.64102525]

----> pbest : [17.64132615]

-----> gbest : 17.641004696680973

iteration : #6

----> pbest : [17.64102056]

----> pbest : [17.64096837]

----> pbest : [17.64115667]

----> pbest : [17.64095988]

----> pbest : [17.64099793]

----> pbest : [17.64093325]

----> pbest : [17.64096783]

----> pbest : [17.64102526]

----> pbest : [17.64095717]

----> pbest : [17.64097397]

-----> gbest : 17.64093324628174

iteration : #7

----> pbest : [17.64094137]

----> pbest : [17.64091736]

----> pbest : [17.640919]

----> pbest : [17.64091902]

----> pbest : [17.64098246]

----> pbest : [17.64091496]

----> pbest : [17.64096783]

----> pbest : [17.64094019]

----> pbest : [17.6409181]

----> pbest : [17.64091371]

-----> gbest : 17.64091371187333

iteration : #8

----> pbest : [17.64091165]

----> pbest : [17.640903]

----> pbest : [17.64090028]

----> pbest : [17.64090605]

----> pbest : [17.64090394]

----> pbest : [17.64090713]

----> pbest : [17.6409273]

----> pbest : [17.64090349]

----> pbest : [17.64090389]

----> pbest : [17.64090208]

-----> gbest : 17.640900275292193

iteration : #9

----> pbest : [17.64090276]

----> pbest : [17.64089307]

----> pbest : [17.64089298]

----> pbest : [17.64090142]

----> pbest : [17.64089568]

----> pbest : [17.64090094]

----> pbest : [17.6408986]

----> pbest : [17.64089538]

----> pbest : [17.64089314]

----> pbest : [17.64089769]

-----> gbest : 17.640892982780997

iteration : #10

----> pbest : [17.64089271]

----> pbest : [17.64089274]

----> pbest : [17.64089275]

----> pbest : [17.64089274]

----> pbest : [17.64089312]

----> pbest : [17.64089299]

----> pbest : [17.64089447]

----> pbest : [17.64089269]

----> pbest : [17.64089276]

----> pbest : [17.64089283]

-----> gbest : 17.640892694795113

The best solution is: [[ -4.63424663 0.05263513 7.72144275 -0.5358549 4.01117288

2.70113193 4.96432799 1.02976066 4.51808367 1.53644242

1.30466726 -9.34720186 -2.28282943 5.56220394 0.7850163

-2.67309587 2.84865864 -4.85635167 3.50303932 -1.42217711

8.18875597 3.04389467 -4.68142164 -2.36519979 0.45459447

-2.08496628 1.67193473 -2.25278753 -6.12612109 -1.16600895

-1.83059511 -0.88509075 -3.78575205 1.49289677 6.14229457

2.13498075 5.38058332 2.9611055 -3.4276075 -2.33471235

-1.07229509 -0.35280585 2.44792662 3.47325528 -3.02529493

8.13606856 3.64802913 -9.36376223 -1.98891858 -1.2274446

2.79112827 -1.53206037 6.22678002 4.98185753 3.86054294

-6.90885883 1.34572518 2.82128504 2.63897507 -3.24745738

-0.89370242 -0.30107164 -8.43388391 3.6022006 -2.52245821

-1.82105822 5.76421064 -2.01042121 -8.38762675 -1.80461842

-1.56565523 5.88278101 3.36822296 1.38077021 10.28235147

-0.92989366 8.15572754 4.35220785 0.88014995 6.18920103

-5.62377551 1.44539229 6.07148998 8.46682685 3.13867726

-5.82008698 -0.02857518 -2.80719076 -2.9229637 -2.21739196

-0.89997537 3.52969218 -1.13000142 -3.63444706 7.32533979

-1.53106574 8.19689741 -2.00961025 9.27150474 5.62749498

2.85552192 -0.67957798 -1.19125386 -0.58698169 9.67680898

-0.52313814 -0.0392246 -3.52310099 -11.34566014 -6.66249311

2.00552575 -2.28340628 -5.2901275 -0.96143622 -0.13623074

-3.48589321 -6.15302685 3.27825264 -0.98279112 5.71570668

2.79299079 -2.16040965 0.5508858 4.8424178 4.09346629

9.28574662 -1.79299835 -4.72179976 4.81886082 8.73513489

4.2536257 -0.33572419 4.43073325 6.16019589 -5.52158759]] in n\_iterations: 10

------------------------- # Round 3 -------------------------

iteration : #1

----> pbest : [18.29456256]

----> pbest : [18.09534698]

----> pbest : [18.08905448]

----> pbest : [17.80441022]

----> pbest : [18.03078746]

----> pbest : [18.2447666]

----> pbest : [18.4427416]

----> pbest : [18.16837847]

----> pbest : [18.00891403]

----> pbest : [18.04697555]

-----> gbest : 17.80441021861099

iteration : #2

----> pbest : [18.09971989]

----> pbest : [17.77347621]

----> pbest : [18.02498381]

----> pbest : [17.80441022]

----> pbest : [17.8117068]

----> pbest : [18.16334338]

----> pbest : [17.76015186]

----> pbest : [17.74573408]

----> pbest : [17.74574133]

----> pbest : [17.75719472]

-----> gbest : 17.745734080967264

iteration : #3

----> pbest : [17.71940703]

----> pbest : [17.67087011]

----> pbest : [17.71038339]

----> pbest : [17.77834588]

----> pbest : [17.71447508]

----> pbest : [17.68707682]

----> pbest : [17.66581255]

----> pbest : [17.69057438]

----> pbest : [17.65844058]

----> pbest : [17.6634368]

-----> gbest : 17.658440583022827

iteration : #4

----> pbest : [17.66506421]

----> pbest : [17.64964556]

----> pbest : [17.64634686]

----> pbest : [17.66704474]

----> pbest : [17.65315294]

----> pbest : [17.65163379]

----> pbest : [17.64961277]

----> pbest : [17.64908426]

----> pbest : [17.64783264]

----> pbest : [17.65351025]

-----> gbest : 17.646346860634168

iteration : #5

----> pbest : [17.64880269]

----> pbest : [17.64494895]

----> pbest : [17.64390871]

----> pbest : [17.64352986]

----> pbest : [17.64541476]

----> pbest : [17.64621533]

----> pbest : [17.64457867]

----> pbest : [17.64671314]

----> pbest : [17.64490608]

----> pbest : [17.64666405]

-----> gbest : 17.643529857239535

iteration : #6

----> pbest : [17.6433181]

----> pbest : [17.64316292]

----> pbest : [17.64324583]

----> pbest : [17.64233442]

----> pbest : [17.64242488]

----> pbest : [17.64331363]

----> pbest : [17.64165116]

----> pbest : [17.64671314]

----> pbest : [17.64297992]

----> pbest : [17.64133584]

-----> gbest : 17.64133584378164

iteration : #7

----> pbest : [17.64098258]

----> pbest : [17.64259201]

----> pbest : [17.64281253]

----> pbest : [17.64099785]

----> pbest : [17.64177348]

----> pbest : [17.64117246]

----> pbest : [17.64128859]

----> pbest : [17.6411671]

----> pbest : [17.64101472]

----> pbest : [17.64098865]

-----> gbest : 17.640982578514574

iteration : #8

----> pbest : [17.6409605]

----> pbest : [17.64096129]

----> pbest : [17.64099179]

----> pbest : [17.64099785]

----> pbest : [17.64094499]

----> pbest : [17.64107564]

----> pbest : [17.64107877]

----> pbest : [17.64109953]

----> pbest : [17.64096798]

----> pbest : [17.64095076]

-----> gbest : 17.640944985108085

iteration : #9

----> pbest : [17.64093045]

----> pbest : [17.6409141]

----> pbest : [17.64096275]

----> pbest : [17.64098357]

----> pbest : [17.64093709]

----> pbest : [17.64093272]

----> pbest : [17.64094314]

----> pbest : [17.64093603]

----> pbest : [17.64093756]

----> pbest : [17.64093122]

-----> gbest : 17.640914103223167

iteration : #10

----> pbest : [17.64091004]

----> pbest : [17.64090329]

----> pbest : [17.64093582]

----> pbest : [17.64090485]

----> pbest : [17.64091003]

----> pbest : [17.64090199]

----> pbest : [17.64090731]

----> pbest : [17.64090232]

----> pbest : [17.64090923]

----> pbest : [17.64091659]

-----> gbest : 17.640901993375405

The best solution is: [[ -2.12943868 -3.53771998 -6.94670445 8.07053471 9.15331

4.37419104 4.31474045 2.42697501 -0.29611292 3.78813626

-0.10496676 -5.13782716 3.93512864 -1.08734151 1.8615294

-4.27221334 2.13965082 0.08831879 -0.57989229 5.57475099

-2.41673389 -6.62989587 -0.02007773 9.50753616 0.78407123

1.19614905 -2.31241076 -4.79343439 -5.38992451 1.33392123

7.7640855 3.5866218 -3.23381578 -4.12679276 -4.44238962

9.49485299 -1.03952372 -1.34748516 -1.73383422 1.53985222

0.78269456 1.39707127 0.65274521 -7.00374611 3.63796105

1.09203792 3.68562928 4.93456545 0.69801604 7.33196372

-2.34188527 6.72066387 -7.60452497 -2.56858503 1.07443698

7.83001796 -1.14966917 0.11035113 -2.85408117 0.52710844

-1.11330329 4.30351794 -6.54441977 -1.91105018 -7.86964705

3.97204715 -8.00863984 0.34643928 -2.76266107 -7.92512162

1.04613744 -3.91972636 2.17453507 9.08663646 0.44126859

-10.40930873 9.03340328 -2.53421608 0.23287832 -2.6431044

3.46477903 2.99611337 -3.02385826 -6.15412787 -5.48776042

1.0998009 5.73389503 1.73704659 -4.56793956 -4.1923089

-2.61381484 3.48866175 -5.31756191 -4.9793671 7.01358128

0.8289558 0.45943245 -3.76325545 -4.62790193 0.11394144

-7.87091768 -5.69016611 -5.77460477 -5.66458612 0.28168829

-4.6429753 7.52224782 1.67797191 -1.22458394 6.49857575

-2.74675755 4.29099472 -5.94756553 4.91923719 3.11569549

4.39679803 -1.96141965 -1.63253577 -1.92936703 -1.00751864

-4.68250989 0.0891407 8.72646566 3.67390169 8.12595894

-1.8248233 -6.24961178 4.33415049 0.2754839 5.98993164

4.85758669 -4.38947878 5.0947316 2.83842961 -7.37896986]] in n\_iterations: 10

------------------------- # Round 4 -------------------------

iteration : #1

----> pbest : [18.24765454]

----> pbest : [18.02358012]

----> pbest : [17.94153171]

----> pbest : [17.85026351]

----> pbest : [18.23054479]

----> pbest : [18.16579144]

----> pbest : [18.00561497]

----> pbest : [17.77067474]

----> pbest : [18.41483695]

----> pbest : [18.03352657]

-----> gbest : 17.770674744683635

iteration : #2

----> pbest : [18.20455048]

----> pbest : [17.76186159]

----> pbest : [17.91388773]

----> pbest : [17.77325159]

----> pbest : [17.90510409]

----> pbest : [17.76817987]

----> pbest : [17.75371165]

----> pbest : [17.77067474]

----> pbest : [17.82815786]

----> pbest : [18.03178765]

-----> gbest : 17.75371165271309

iteration : #3

----> pbest : [18.16694428]

----> pbest : [17.76186159]

----> pbest : [17.80938898]

----> pbest : [17.77325159]

----> pbest : [17.70026931]

----> pbest : [17.73138172]

----> pbest : [17.70698065]

----> pbest : [17.76856085]

----> pbest : [17.70714732]

----> pbest : [17.7333175]

-----> gbest : 17.700269310141742

iteration : #4

----> pbest : [18.01067493]

----> pbest : [17.72369492]

----> pbest : [17.70345506]

----> pbest : [17.70012307]

----> pbest : [17.65933633]

----> pbest : [17.68077478]

----> pbest : [17.69602717]

----> pbest : [17.6936119]

----> pbest : [17.67673297]

----> pbest : [17.67237205]

-----> gbest : 17.65933632524989

iteration : #5

----> pbest : [17.71407529]

----> pbest : [17.67538864]

----> pbest : [17.65424235]

----> pbest : [17.66449263]

----> pbest : [17.65045399]

----> pbest : [17.66196614]

----> pbest : [17.65550392]

----> pbest : [17.66383874]

----> pbest : [17.65613397]

----> pbest : [17.64999521]

-----> gbest : 17.649995214067932

iteration : #6

----> pbest : [17.64507993]

----> pbest : [17.65399454]

----> pbest : [17.64487084]

----> pbest : [17.6478314]

----> pbest : [17.64732109]

----> pbest : [17.653914]

----> pbest : [17.65550392]

----> pbest : [17.64779334]

----> pbest : [17.64986833]

----> pbest : [17.64747307]

-----> gbest : 17.644870836118436

iteration : #7

----> pbest : [17.64206977]

----> pbest : [17.64374756]

----> pbest : [17.64331665]

----> pbest : [17.64432206]

----> pbest : [17.6449244]

----> pbest : [17.6460392]

----> pbest : [17.64415779]

----> pbest : [17.64455327]

----> pbest : [17.64641426]

----> pbest : [17.64396854]

-----> gbest : 17.642069771457184

iteration : #8

----> pbest : [17.6415885]

----> pbest : [17.64178621]

----> pbest : [17.64237702]

----> pbest : [17.64267948]

----> pbest : [17.64240538]

----> pbest : [17.64327011]

----> pbest : [17.64415779]

----> pbest : [17.64168825]

----> pbest : [17.64295624]

----> pbest : [17.64132213]

-----> gbest : 17.641322125203498

iteration : #9

----> pbest : [17.64115667]

----> pbest : [17.64129897]

----> pbest : [17.64149377]

----> pbest : [17.64148049]

----> pbest : [17.64122973]

----> pbest : [17.64212321]

----> pbest : [17.6412796]

----> pbest : [17.64124836]

----> pbest : [17.6419695]

----> pbest : [17.64132213]

-----> gbest : 17.64115666983991

iteration : #10

----> pbest : [17.64115667]

----> pbest : [17.641258]

----> pbest : [17.64137385]

----> pbest : [17.64122918]

----> pbest : [17.64119994]

----> pbest : [17.64177552]

----> pbest : [17.6412796]

----> pbest : [17.64124836]

----> pbest : [17.64159943]

----> pbest : [17.64132213]

-----> gbest : 17.64115666983991

The best solution is: [[-3.92824339e+00 -2.99123390e+00 -1.97796951e+00 -4.52116857e-01

-3.54546234e+00 1.55706631e-02 2.13506527e+00 3.04750285e-01

2.98114930e+00 -4.04173510e+00 -6.35817694e-01 2.53196227e+00

1.35981054e+00 -2.92412951e-01 8.45461893e-01 1.23922120e+00

3.88884622e-03 1.07435466e+00 -9.29150452e-01 -1.71039302e+00

-4.85633584e+00 1.13144535e+00 2.04182045e+00 -2.70269319e+00

-1.91649106e+00 -2.03348626e-01 4.37151680e+00 -3.13671780e+00

2.21773580e+00 4.12764335e+00 -3.29514174e+00 2.03090965e+00

-8.75515319e-01 6.93890639e-01 -3.81276737e+00 -2.61697001e+00

3.36086732e+00 4.13135537e+00 3.31883413e+00 -5.29518845e-01

2.78870218e+00 1.23598775e+00 1.25795502e+00 6.75869945e-01

2.22083869e+00 -2.16450850e+00 1.01165450e+00 1.31472057e+00

-4.95315289e-01 -2.30498205e-01 4.47038027e-01 -1.52048808e+00

1.70029259e+00 1.14781871e+00 -9.77098981e-01 6.94207370e-01

-1.94588830e+00 4.17659720e+00 2.29741823e+00 4.41746086e+00

3.62587527e+00 -1.35505748e+00 3.14505667e+00 -3.95276045e+00

-1.44317119e+00 -2.09117074e+00 -4.20047635e-01 2.57179232e+00

3.44115219e+00 7.13900816e-01 4.13479427e+00 2.83224744e+00

-1.25546412e+00 -1.87644365e+00 3.10037727e+00 -1.87058706e+00

2.60379528e-01 -1.78322983e+00 1.04479556e+00 4.82362243e-01

-9.87425214e-01 1.61115372e+00 9.54930276e-01 1.68115062e+00

-2.50130609e+00 2.02435348e+00 -2.70911115e+00 -1.67054381e+00

-2.77256925e+00 -1.78292608e+00 4.68925891e-01 1.73928324e-01

-6.33985687e-01 2.40020145e+00 3.14550715e+00 -1.54334200e+00

-3.72445116e+00 1.83591577e+00 3.21075032e+00 3.37441222e+00

3.78713076e+00 -5.51687135e-01 3.11319148e+00 3.59698269e+00

9.95559483e-01 -4.46491146e+00 -3.10364549e+00 -4.15327102e-01

2.08320614e+00 -1.95226172e+00 2.17043519e+00 -4.08875204e+00

3.00370351e-01 -3.89386186e+00 -2.41271767e+00 2.83654400e+00

2.43326003e+00 -4.12516313e-01 -2.56796736e+00 1.79234534e+00

2.49034276e+00 5.20198784e-01 2.95017351e-01 2.09678194e+00

2.25868621e+00 -4.53762434e+00 2.98059054e+00 3.44148580e+00

3.96845666e-01 1.84832133e-01 -2.56926946e-01 1.67897563e+00

3.21055335e-01 2.78129412e-01 2.08260914e+00]] in n\_iterations: 10

------------------------- # Round 5 -------------------------

iteration : #1

----> pbest : [18.29657656]

----> pbest : [18.36909368]

----> pbest : [17.67585772]

----> pbest : [17.9282217]

----> pbest : [18.45000953]

----> pbest : [18.1839738]

----> pbest : [18.27221366]

----> pbest : [18.10557993]

----> pbest : [17.67993734]

----> pbest : [18.23752677]

-----> gbest : 17.675857719355285

iteration : #2

----> pbest : [17.67954788]

----> pbest : [17.6547127]

----> pbest : [17.67585772]

----> pbest : [17.86268853]

----> pbest : [18.26696195]

----> pbest : [17.67168644]

----> pbest : [18.25602935]

----> pbest : [17.95588994]

----> pbest : [17.66499143]

----> pbest : [17.77013484]

-----> gbest : 17.654712703051374

iteration : #3

----> pbest : [17.64353718]

----> pbest : [17.64186571]

----> pbest : [17.65228374]

----> pbest : [17.68132769]

----> pbest : [17.64800654]

----> pbest : [17.64164574]

----> pbest : [17.64525141]

----> pbest : [17.76475098]

----> pbest : [17.6430629]

----> pbest : [17.680333]

-----> gbest : 17.641645744700085

iteration : #4

----> pbest : [17.64109661]

----> pbest : [17.64110287]

----> pbest : [17.64162046]

----> pbest : [17.64117503]

----> pbest : [17.64096911]

----> pbest : [17.64102275]

----> pbest : [17.64103867]

----> pbest : [17.64114667]

----> pbest : [17.64122051]

----> pbest : [17.65273212]

-----> gbest : 17.640969114708284

iteration : #5

----> pbest : [17.64093577]

----> pbest : [17.64095529]

----> pbest : [17.64093672]

----> pbest : [17.64102595]

----> pbest : [17.64090565]

----> pbest : [17.64093804]

----> pbest : [17.64099051]

----> pbest : [17.64098776]

----> pbest : [17.64094507]

----> pbest : [17.64090528]

-----> gbest : 17.640905279351703

iteration : #6

----> pbest : [17.64091961]

----> pbest : [17.64091283]

----> pbest : [17.64089599]

----> pbest : [17.64089784]

----> pbest : [17.64089851]

----> pbest : [17.6409133]

----> pbest : [17.64096932]

----> pbest : [17.64089635]

----> pbest : [17.64090267]

----> pbest : [17.6408942]

-----> gbest : 17.640894201728837

iteration : #7

----> pbest : [17.64089779]

----> pbest : [17.64089571]

----> pbest : [17.6408931]

----> pbest : [17.64089322]

----> pbest : [17.64089537]

----> pbest : [17.6408973]

----> pbest : [17.64089355]

----> pbest : [17.64089304]

----> pbest : [17.64089439]

----> pbest : [17.64089311]

-----> gbest : 17.640893035179527

iteration : #8

----> pbest : [17.64089394]

----> pbest : [17.64089254]

----> pbest : [17.64089272]

----> pbest : [17.64089253]

----> pbest : [17.64089254]

----> pbest : [17.64089253]

----> pbest : [17.64089255]

----> pbest : [17.64089253]

----> pbest : [17.64089323]

----> pbest : [17.64089255]

-----> gbest : 17.64089252897281

iteration : #9

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089282]

----> pbest : [17.64089253]

-----> gbest : 17.6408925201901

iteration : #10

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089267]

----> pbest : [17.64089252]

-----> gbest : 17.64089251912668

The best solution is: [[-5.00144056e-01 1.66516043e+00 -2.66354133e+00 -1.13795470e+00

6.75715889e+00 2.87807566e+00 3.33055286e+00 -5.51299790e+00

-8.15852785e+00 -9.50293992e-01 3.69561225e+00 -4.00781277e+00

-3.05914054e+00 7.21441021e+00 3.72867389e+00 8.07538612e+00

2.85534389e+00 -5.63889407e+00 2.40530722e+00 -7.11592185e+00

-5.21913317e+00 6.60485532e+00 1.27930843e+00 2.70803294e+00

-6.64797665e+00 -1.61226227e+00 -3.69709238e+00 5.17517967e-01

-7.12005171e+00 5.64401079e+00 2.34902386e+00 -3.15240103e+00

-4.38330809e+00 8.00524845e-01 6.26410502e+00 3.42490273e-01

-1.98166846e+00 3.34643732e+00 2.42011745e-01 -4.12156811e+00

-5.39662131e+00 5.40032361e+00 2.01604210e+00 4.04009194e+00

2.40943094e+00 9.48105880e-01 3.02199530e+00 5.39903683e+00

1.14298851e+00 3.35817552e+00 -1.67378479e+00 1.18074030e+00

5.80366192e+00 -6.25929417e+00 5.93569916e+00 1.99212951e+00

1.38927509e+00 4.06522065e+00 -7.44887711e-02 -3.77873415e+00

-5.12526906e+00 3.77126146e+00 -1.33883276e+00 -3.15377286e+00

-1.66652172e+00 1.04920753e+00 3.81293611e+00 -5.03617082e+00

-4.16601345e+00 2.32655161e+00 3.61358703e+00 -1.44269361e+00

-7.46008523e-01 1.75966122e+00 -5.19314817e+00 3.73721429e+00

8.10625777e-03 -2.84350122e+00 -8.86962151e-01 -4.54692412e+00

1.60234130e+00 4.05962644e+00 -8.10429775e-01 -4.25124016e+00

3.18242457e+00 1.73399489e+00 -5.74164826e+00 1.82530502e+00

6.81446301e-01 2.94255908e+00 -3.52794554e+00 9.82297714e-01

1.42137404e+00 -9.67122390e-01 3.91774600e+00 7.63291157e+00

2.33165554e+00 -5.95533757e+00 5.43282601e+00 3.25499758e+00

-2.97072189e+00 2.42187954e+00 3.08081812e+00 3.90136918e+00

-1.64163020e+00 -4.07516904e+00 6.28975547e+00 1.19284201e+00

-2.45471515e+00 4.43214066e+00 -4.64423143e+00 -4.16530501e+00

-4.25764477e+00 1.16331372e+00 -8.96581356e+00 1.03582590e+00

6.94344682e+00 -2.39789392e+00 9.86728293e-01 -4.24871754e+00

2.54431566e+00 3.93968644e+00 5.65532909e+00 5.01918587e+00

2.10735772e+00 5.36328717e+00 4.12101270e+00 -8.74950309e-02

-2.18949329e+00 -5.18907630e+00 3.60686203e+00 7.45454674e-01

1.09062966e+01 5.88626321e+00 -2.14043934e+00]] in n\_iterations: 10

------------------------- # Round 6 -------------------------

iteration : #1

----> pbest : [18.32279315]

----> pbest : [18.3236171]

----> pbest : [18.39767154]

----> pbest : [18.18659145]

----> pbest : [17.92729825]

----> pbest : [17.90883867]

----> pbest : [17.74651975]

----> pbest : [18.33176866]

----> pbest : [18.03332945]

----> pbest : [17.95844427]

-----> gbest : 17.74651974946118

iteration : #2

----> pbest : [17.85054139]

----> pbest : [17.6812182]

----> pbest : [17.83831033]

----> pbest : [17.70925054]

----> pbest : [17.92729825]

----> pbest : [17.82439065]

----> pbest : [17.74651975]

----> pbest : [18.2225988]

----> pbest : [17.84842768]

----> pbest : [17.71120301]

-----> gbest : 17.68121820363464

iteration : #3

----> pbest : [17.6688072]

----> pbest : [17.64190407]

----> pbest : [17.66323872]

----> pbest : [17.65143635]

----> pbest : [17.75103851]

----> pbest : [17.66616457]

----> pbest : [17.68166855]

----> pbest : [17.65271784]

----> pbest : [17.65580398]

----> pbest : [17.65242092]

-----> gbest : 17.641904065291115

iteration : #4

----> pbest : [17.6411917]

----> pbest : [17.64105926]

----> pbest : [17.64472545]

----> pbest : [17.64394466]

----> pbest : [17.64526944]

----> pbest : [17.64129067]

----> pbest : [17.65628705]

----> pbest : [17.64143034]

----> pbest : [17.64207478]

----> pbest : [17.64105424]

-----> gbest : 17.641054243478045

iteration : #5

----> pbest : [17.640911]

----> pbest : [17.64095034]

----> pbest : [17.64093224]

----> pbest : [17.64178173]

----> pbest : [17.64123284]

----> pbest : [17.64093724]

----> pbest : [17.64447144]

----> pbest : [17.64091408]

----> pbest : [17.64113642]

----> pbest : [17.64093204]

-----> gbest : 17.640910996656654

iteration : #6

----> pbest : [17.64089825]

----> pbest : [17.64090687]

----> pbest : [17.64089456]

----> pbest : [17.64094176]

----> pbest : [17.6409004]

----> pbest : [17.64090025]

----> pbest : [17.64121266]

----> pbest : [17.64090112]

----> pbest : [17.64089636]

----> pbest : [17.64089936]

-----> gbest : 17.640894562531752

iteration : #7

----> pbest : [17.64089512]

----> pbest : [17.6408938]

----> pbest : [17.64089307]

----> pbest : [17.64089993]

----> pbest : [17.64089278]

----> pbest : [17.64089419]

----> pbest : [17.64094357]

----> pbest : [17.64089588]

----> pbest : [17.6408933]

----> pbest : [17.64089456]

-----> gbest : 17.640892782893797

iteration : #8

----> pbest : [17.64089369]

----> pbest : [17.64089261]

----> pbest : [17.64089263]

----> pbest : [17.64089287]

----> pbest : [17.64089259]

----> pbest : [17.64089373]

----> pbest : [17.64089632]

----> pbest : [17.64089354]

----> pbest : [17.64089285]

----> pbest : [17.6408937]

-----> gbest : 17.640892588242608

iteration : #9

----> pbest : [17.64089272]

----> pbest : [17.64089254]

----> pbest : [17.64089256]

----> pbest : [17.64089259]

----> pbest : [17.64089255]

----> pbest : [17.64089256]

----> pbest : [17.64089253]

----> pbest : [17.6408926]

----> pbest : [17.64089273]

----> pbest : [17.64089296]

-----> gbest : 17.640892529589674

iteration : #10

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089253]

----> pbest : [17.64089252]

----> pbest : [17.64089254]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089252]

----> pbest : [17.64089253]

----> pbest : [17.64089263]

-----> gbest : 17.64089251969414

The best solution is: [[ 2.43509292 -1.83663071 -2.3971459 0.74558339 3.73236351

3.84846985 3.73569487 -2.54109208 -0.06362172 4.38643136

0.42745483 -4.13576134 -12.25941057 -6.21192255 -5.50647104

4.12439037 -1.24077674 2.49635704 -4.80589621 10.36192079

1.82387767 5.08042529 7.42709412 -0.30239424 5.58594372

-4.95233951 -10.0569457 -0.2389049 -2.57680622 -0.41764209

-0.35134595 11.34002753 0.82219096 -6.40883369 0.96964011

-11.91211276 -10.1517974 -1.89651018 -0.73240389 -4.78599436

-0.70636997 9.84910388 -2.38793416 5.74361235 0.09859675

12.06487025 -4.77569736 8.06952828 6.90425673 -4.12181697

-3.99591864 -6.14603985 -3.07097321 0.7057933 -2.56742799

5.84059296 6.99613573 3.62995715 3.69791862 -2.1620643

3.3226107 7.13150447 -0.89978261 3.86003679 -2.04693518

0.83708668 1.19308713 0.88542158 -0.54209705 6.12967756

4.85680091 -1.73066293 0.57264617 -1.73124332 1.53276398

7.90893778 -5.12893261 -9.83996443 6.60241463 -4.29565129

-10.58492805 -3.82206663 -9.1054801 -0.9371625 5.98482107

5.13037317 6.13537015 -3.16515827 9.41638385 -4.4613915

-1.82735562 -0.82764114 9.42123828 7.86090314 -2.96760674

-3.39839783 -7.4145279 -3.00605063 -2.05778912 6.91636765

3.87226356 -0.11945596 -0.35241427 -6.48885944 -1.79612548

3.9362412 -7.21263878 -1.38304727 4.37554039 0.11818144

-8.69136617 2.53912981 -9.21361565 6.11910256 6.21333563

3.20114257 -0.5107796 0.91726933 -5.55304573 0.06394098

1.71999509 2.89840583 -0.39362491 5.41690075 2.48143191

7.36923133 0.61538875 6.17639063 2.3899186 4.51100531

7.46666736 9.32373539 -1.35349404 -2.39365395 -2.29637104]] in n\_iterations: 10

------------------------- # Round 7 -------------------------

iteration : #1

----> pbest : [18.09685787]

----> pbest : [17.66480758]

----> pbest : [17.9826997]

----> pbest : [18.31793294]

----> pbest : [18.25550297]

----> pbest : [18.06093878]

----> pbest : [18.37427642]

----> pbest : [18.19369605]

----> pbest : [18.42141099]

----> pbest : [18.16496794]

-----> gbest : 17.66480758420732

iteration : #2

----> pbest : [17.64701302]

----> pbest : [17.66480758]

----> pbest : [17.93068052]

----> pbest : [17.66340744]

----> pbest : [17.70277898]

----> pbest : [17.71675493]

----> pbest : [17.67734264]

----> pbest : [17.67645771]

----> pbest : [17.79988893]

----> pbest : [17.6490116]

-----> gbest : 17.647013016429238

iteration : #3

----> pbest : [17.63001617]

----> pbest : [17.64366745]

----> pbest : [17.66778301]

----> pbest : [17.65096697]

----> pbest : [17.62866957]

----> pbest : [17.62894469]

----> pbest : [17.62858815]

----> pbest : [17.6287223]

----> pbest : [17.63993301]

----> pbest : [17.63092613]

-----> gbest : 17.62858815035963

iteration : #4

----> pbest : [17.62808201]

----> pbest : [17.6279911]

----> pbest : [17.64214783]

----> pbest : [17.63176917]

----> pbest : [17.62774146]

----> pbest : [17.62775165]

----> pbest : [17.62783654]

----> pbest : [17.62776042]

----> pbest : [17.62790776]

----> pbest : [17.62806356]

-----> gbest : 17.627741463016058

iteration : #5

----> pbest : [17.62760054]

----> pbest : [17.62769542]

----> pbest : [17.62811422]

----> pbest : [17.62763775]

----> pbest : [17.62762251]

----> pbest : [17.62762459]

----> pbest : [17.62757835]

----> pbest : [17.62762631]

----> pbest : [17.62758778]

----> pbest : [17.62760586]

-----> gbest : 17.627578345291305

iteration : #6

----> pbest : [17.62756196]

----> pbest : [17.62757287]

----> pbest : [17.62761168]

----> pbest : [17.62763775]

----> pbest : [17.62762251]

----> pbest : [17.62756217]

----> pbest : [17.62757835]

----> pbest : [17.62756065]

----> pbest : [17.62758778]

----> pbest : [17.62760586]

-----> gbest : 17.627560651850956

iteration : #7

----> pbest : [17.62755083]

----> pbest : [17.62754549]

----> pbest : [17.62753542]

----> pbest : [17.62763775]

----> pbest : [17.62756185]

----> pbest : [17.62756217]

----> pbest : [17.62757835]

----> pbest : [17.62756065]

----> pbest : [17.62758778]

----> pbest : [17.62755623]

-----> gbest : 17.62753542034792

iteration : #8

----> pbest : [17.62753681]

----> pbest : [17.62754549]

----> pbest : [17.62753396]

----> pbest : [17.62763775]

----> pbest : [17.62753539]

----> pbest : [17.62755776]

----> pbest : [17.62754324]

----> pbest : [17.62753539]

----> pbest : [17.62755019]

----> pbest : [17.62753599]

-----> gbest : 17.627533961612027

iteration : #9

----> pbest : [17.62753364]

----> pbest : [17.62753257]

----> pbest : [17.62753333]

----> pbest : [17.62753469]

----> pbest : [17.62753192]

----> pbest : [17.62753272]

----> pbest : [17.62753252]

----> pbest : [17.62753255]

----> pbest : [17.62753277]

----> pbest : [17.62753268]

-----> gbest : 17.627531916955483

iteration : #10

----> pbest : [17.62753208]

----> pbest : [17.62753164]

----> pbest : [17.62753154]

----> pbest : [17.62753297]

----> pbest : [17.62753134]

----> pbest : [17.62753112]

----> pbest : [17.62753119]

----> pbest : [17.62753162]

----> pbest : [17.62753114]

----> pbest : [17.62753161]

-----> gbest : 17.62753111699682

The best solution is: [[ 3.03845046 -3.89302501 6.8836846 -3.65777431 1.86283443 1.43343328

-4.96547967 5.04809082 6.93648495 1.37795872 2.50468218 -2.31293199

5.33628226 0.59975596 -3.81059698 2.37812957 -5.19302163 -4.40015623

3.79643068 -0.15275569 -1.03055298 0.17189295 3.06583779 -2.82263967

-1.67614546 0.71572627 3.06850371 0.3543676 -2.63683435 -1.6944723

-0.99258626 2.22522225 -2.02939019 -4.53342838 2.02473246 2.94769794

-0.26799636 3.06895559 0.32937018 -4.05963258 -1.69653127 -2.48960976

-0.94284363 6.00155526 1.77615118 -3.35601453 1.41712398 -0.18446832

3.32085721 -3.92824456 -0.56432923 -3.66136151 -1.98853121 -1.60470451

-1.83391117 -0.80808988 -0.7215308 3.22651541 5.25352898 -3.41520272

-5.11453651 0.77806725 -3.53078047 1.98851168 -1.51835112 -0.45997538

0.41814344 -2.45130866 -0.35589287 2.04513877 -3.04412272 -4.1766506

0.80109617 3.56804231 0.47218764 -0.33929782 4.23753738 2.0290496

2.02423098 -4.20790334 0.18245229 2.09576958 -3.55699718 -0.76592377

-1.37306982 -2.90870276 2.82025723 1.61900829 -0.7929491 -3.08939143

-5.083387 6.4687556 -1.21491357 -1.40090923 -2.82685816 0.33292688

1.87966282 5.47256838 0.39856228 -3.86243177 -0.16933868 -4.55422489

2.46625149 -1.22494787 2.15122353 -1.19197596 -2.68812126 -3.10237754

-5.01008791 1.72624023 0.36694433 4.32441216 -0.39438727 -0.38146583

-1.86062052 -0.56651296 5.23162461 1.00364915 4.03412297 1.11412929

-4.77627618 1.38247937 3.40829841 -5.63039498 2.01424135 -1.57061381

-1.43828547 7.48611472 3.72784713 5.02120003 4.48679912 -0.80548107

3.36370269 3.60545087 -4.84759301]] in n\_iterations: 10

------------------------- # Round 8 -------------------------

iteration : #1

----> pbest : [17.96367372]

----> pbest : [18.35497616]

----> pbest : [18.23184493]

----> pbest : [17.80490356]

----> pbest : [17.82400146]

----> pbest : [17.88444431]

----> pbest : [17.73269313]

----> pbest : [17.99400671]

----> pbest : [17.98115452]

----> pbest : [17.90595581]

-----> gbest : 17.732693125912633

iteration : #2

----> pbest : [17.88251319]

----> pbest : [17.82391392]

----> pbest : [18.12256298]

----> pbest : [17.80490356]

----> pbest : [17.72559131]

----> pbest : [17.7732354]

----> pbest : [17.73269313]

----> pbest : [17.74818965]

----> pbest : [17.93149532]

----> pbest : [17.8983068]

-----> gbest : 17.72559131368844

iteration : #3

----> pbest : [17.73325149]

----> pbest : [17.67392002]

----> pbest : [17.68025779]

----> pbest : [17.80490356]

----> pbest : [17.69097842]

----> pbest : [17.7732354]

----> pbest : [17.73184471]

----> pbest : [17.66819638]

----> pbest : [17.73193213]

----> pbest : [17.76697089]

-----> gbest : 17.66819638090788

iteration : #4

----> pbest : [17.69825749]

----> pbest : [17.65544295]

----> pbest : [17.64740412]

----> pbest : [17.6537411]

----> pbest : [17.67960587]

----> pbest : [17.66828726]

----> pbest : [17.66554035]

----> pbest : [17.66454655]

----> pbest : [17.70297339]

----> pbest : [17.65013556]

-----> gbest : 17.647404120121596

iteration : #5

----> pbest : [17.6552077]

----> pbest : [17.64302547]

----> pbest : [17.64219119]

----> pbest : [17.63604793]

----> pbest : [17.6614686]

----> pbest : [17.63884548]

----> pbest : [17.6456863]

----> pbest : [17.64388172]

----> pbest : [17.65606863]

----> pbest : [17.63409969]

-----> gbest : 17.634099687521957

iteration : #6

----> pbest : [17.63985088]

----> pbest : [17.63465686]

----> pbest : [17.63991967]

----> pbest : [17.63604793]

----> pbest : [17.64053489]

----> pbest : [17.63616339]

----> pbest : [17.635022]

----> pbest : [17.63465332]

----> pbest : [17.63527568]

----> pbest : [17.63409969]

-----> gbest : 17.634099687521957

iteration : #7

----> pbest : [17.63526284]

----> pbest : [17.63465686]

----> pbest : [17.6346536]

----> pbest : [17.63440711]

----> pbest : [17.63373744]

----> pbest : [17.63613199]

----> pbest : [17.635022]

----> pbest : [17.63465332]

----> pbest : [17.63527568]

----> pbest : [17.63409969]

-----> gbest : 17.633737440895953

iteration : #8

----> pbest : [17.63517725]

----> pbest : [17.63460598]

----> pbest : [17.63419992]

----> pbest : [17.63440711]

----> pbest : [17.63373744]

----> pbest : [17.63533809]

----> pbest : [17.634562]

----> pbest : [17.63398913]

----> pbest : [17.63505524]

----> pbest : [17.6336239]

-----> gbest : 17.633623903607926

iteration : #9

----> pbest : [17.63351755]

----> pbest : [17.63356619]

----> pbest : [17.63397327]

----> pbest : [17.63440711]

----> pbest : [17.63373744]

----> pbest : [17.63533809]

----> pbest : [17.63346024]

----> pbest : [17.63376837]

----> pbest : [17.63505524]

----> pbest : [17.6336239]

-----> gbest : 17.633460238992587

iteration : #10

----> pbest : [17.63351755]

----> pbest : [17.63356619]

----> pbest : [17.63344119]

----> pbest : [17.63440711]

----> pbest : [17.63373744]

----> pbest : [17.63533809]

----> pbest : [17.63346024]

----> pbest : [17.63376837]

----> pbest : [17.63505524]

----> pbest : [17.63353489]

-----> gbest : 17.633441193895866

The best solution is: [[-1.97488502e+00 8.56539634e-01 3.33317485e+00 6.62995522e-01

-1.60087568e+00 1.43892986e+00 -2.41782241e+00 1.70059082e+00

2.26514975e+00 2.88732619e+00 3.35212126e-01 1.09561697e+00

5.46589034e-01 1.85436440e+00 3.23400065e-01 1.34048749e+00

-2.22922330e+00 -1.45622036e-01 -3.60522393e+00 -1.56101740e+00

-4.14499749e-01 1.87157243e+00 1.12566642e+00 -1.55315401e-01

1.92998268e-01 2.80899985e+00 2.83525633e+00 -1.41188133e+00

-1.86986754e+00 1.47774060e+00 7.54993902e-01 1.04998136e+00

1.11024823e+00 1.89351310e+00 -1.18896777e+00 2.45430824e+00

-4.03544679e-02 -1.31893980e+00 4.82212656e-01 3.89778892e+00

1.71606022e+00 1.20218736e+00 6.04009198e-01 1.37973563e+00

-2.54257345e-01 1.85237379e+00 5.12009546e-01 -2.70457802e+00

-1.00678533e+00 -1.05777864e+00 -1.77611254e-01 1.59107114e+00

1.29760205e+00 2.06901532e-01 -1.37473910e+00 1.46010174e+00

-2.16999472e+00 -3.31973701e-01 -4.54486477e-02 -2.12905085e+00

-2.58383488e-01 -4.21071496e-01 1.29194148e+00 2.21492285e+00

-1.49998810e+00 -5.06862477e-01 -1.50744962e+00 -1.68578232e+00

2.47547701e+00 1.08937963e+00 2.22016768e+00 -1.68174881e+00

1.93603657e+00 1.65762012e+00 -1.04286863e+00 2.53679179e+00

9.83905508e-01 -2.00958210e+00 -1.94769316e-03 1.84417551e-01

1.92774821e-01 -9.44687265e-01 2.59434243e-01 -4.01520777e-01

1.92734269e+00 1.19939166e+00 -2.36121635e+00 2.45755004e+00

-1.14828785e+00 3.12016287e+00 -5.58235893e-01 1.74511620e+00

3.20944300e+00 -1.48518087e+00 1.26955437e+00 5.88334038e-03

7.20614627e-01 -3.67847861e+00 -1.04536562e-01 -1.18798665e+00

-9.68787715e-01 2.69587141e+00 1.00934056e-01 -8.95458360e-01

-9.55337186e-01 -1.93830539e+00 -1.93373405e+00 3.56369696e+00

-1.02075270e+00 1.41684472e+00 -4.92276543e-01 -8.70319284e-01

-9.89676094e-01 1.15956246e+00 5.84272040e-01 2.34659076e+00

2.72415349e+00 -2.55128934e+00 -6.95392297e-02 -2.65753069e+00

-2.18721228e+00 6.83366725e-02 1.15616136e+00 2.49330992e+00

1.93752626e+00 2.09332817e-01 1.35041155e+00 -3.43419891e-01

3.70609757e-01 -2.97553207e+00 2.48069109e-01 2.80706493e+00

1.45062207e+00 4.18398922e-01 1.61216846e+00]] in n\_iterations: 10

------------------------- # Round 9 -------------------------

iteration : #1

----> pbest : [18.24306742]

----> pbest : [18.02237882]

----> pbest : [18.17743997]

----> pbest : [18.19843893]

----> pbest : [18.3561632]

----> pbest : [18.49234695]

----> pbest : [18.26576765]

----> pbest : [18.36612859]

----> pbest : [17.98864339]

----> pbest : [18.17003775]

-----> gbest : 17.98864338876041

iteration : #2

----> pbest : [18.19217145]

----> pbest : [17.99338821]

----> pbest : [17.7430393]

----> pbest : [18.06363931]

----> pbest : [18.01918925]

----> pbest : [17.99583534]

----> pbest : [18.03201586]

----> pbest : [18.30296385]

----> pbest : [17.98864339]

----> pbest : [17.73862878]

-----> gbest : 17.738628778360493

iteration : #3

----> pbest : [17.69438884]

----> pbest : [17.95454076]

----> pbest : [17.60909544]

----> pbest : [17.89852509]

----> pbest : [17.70987151]

----> pbest : [17.70464691]

----> pbest : [18.03201586]

----> pbest : [17.63151083]

----> pbest : [17.91733761]

----> pbest : [17.61786306]

-----> gbest : 17.60909544061025

iteration : #4

----> pbest : [17.64492025]

----> pbest : [17.62555328]

----> pbest : [17.60177874]

----> pbest : [17.61546683]

----> pbest : [17.61005823]

----> pbest : [17.6032394]

----> pbest : [18.03201586]

----> pbest : [17.59835069]

----> pbest : [17.71395348]

----> pbest : [17.60665171]

-----> gbest : 17.598350687974428

iteration : #5

----> pbest : [17.61372746]

----> pbest : [17.59790299]

----> pbest : [17.59800842]

----> pbest : [17.5976252]

----> pbest : [17.59808151]

----> pbest : [17.59772958]

----> pbest : [18.03201586]

----> pbest : [17.59776554]

----> pbest : [17.61836353]

----> pbest : [17.6008775]

-----> gbest : 17.5976252016884

iteration : #6

----> pbest : [17.59759221]

----> pbest : [17.59777408]

----> pbest : [17.59773747]

----> pbest : [17.59758651]

----> pbest : [17.59756033]

----> pbest : [17.59761713]

----> pbest : [17.59763347]

----> pbest : [17.59765444]

----> pbest : [17.59776226]

----> pbest : [17.59772094]

-----> gbest : 17.597560331006395

iteration : #7

----> pbest : [17.5975549]

----> pbest : [17.59763284]

----> pbest : [17.59755746]

----> pbest : [17.59757557]

----> pbest : [17.59755539]

----> pbest : [17.59757938]

----> pbest : [17.59756096]

----> pbest : [17.59758887]

----> pbest : [17.59757491]

----> pbest : [17.59755541]

-----> gbest : 17.597554901003722

iteration : #8

----> pbest : [17.59755336]

----> pbest : [17.59755962]

----> pbest : [17.59755363]

----> pbest : [17.59755332]

----> pbest : [17.5975535]

----> pbest : [17.59755435]

----> pbest : [17.59755355]

----> pbest : [17.5975537]

----> pbest : [17.59755535]

----> pbest : [17.59755353]

-----> gbest : 17.597553315472954

iteration : #9

----> pbest : [17.59755336]

----> pbest : [17.59755344]

----> pbest : [17.5975536]

----> pbest : [17.59755332]

----> pbest : [17.5975535]

----> pbest : [17.59755435]

----> pbest : [17.59755355]

----> pbest : [17.59755344]

----> pbest : [17.59755383]

----> pbest : [17.59755353]

-----> gbest : 17.597553315472954

iteration : #10

----> pbest : [17.59755334]

----> pbest : [17.59755311]

----> pbest : [17.59755346]

----> pbest : [17.59755332]

----> pbest : [17.59755334]

----> pbest : [17.59755435]

----> pbest : [17.59755355]

----> pbest : [17.59755338]

----> pbest : [17.59755353]

----> pbest : [17.59755333]

-----> gbest : 17.597553108240785

The best solution is: [[ 3.68541099 1.17995523 -5.12649551 0.11856028 2.75701412 -6.4502716

1.44270168 1.126745 -2.59511044 -3.80975741 -1.42845994 -1.978687

0.15825789 -2.98585587 1.69582401 -3.28916841 -1.65539933 -1.48864844

3.65394296 -5.76718161 0.50489541 7.18765295 -4.76069577 5.75811941

-4.44817487 -2.90249523 2.65946154 0.56384006 -0.68676011 -2.25385067

-2.99193343 -0.96730383 -2.73271029 1.29950323 -4.02721399 0.08016797

-2.35228747 -1.2582923 -3.75538429 -3.31416941 1.93135994 3.51951414

-1.25673079 -2.24857077 -4.93210906 5.27375485 -2.99159398 1.30159528

-0.88151166 -2.51061344 -4.35162362 1.79887215 0.75202798 -1.64019652

-3.9045928 2.80946466 6.52809062 3.2681188 -4.32540649 4.13081869

1.93738199 -0.56949391 3.32236271 -0.92673077 3.93604633 -5.39715863

6.8879065 4.01175905 2.11077587 -0.72404864 3.17969903 5.81864196

-5.82697226 5.27331741 2.65262567 1.18201255 -5.39780927 4.73892442

4.70010983 1.14219477 1.0808823 -4.45483801 -1.94781135 -3.38533228

-0.8364854 -0.42085407 -2.4128965 2.42926789 4.64607755 2.5661814

-3.30468307 -1.86116872 -3.74322896 4.16380608 2.54010653 -2.95122331

2.93545957 3.22833894 1.31707336 1.89761735 -4.62811087 3.12495742

-7.88722732 -5.70431944 -3.54909809 3.36070154 5.93798134 -1.31460049

0.18017363 2.58527488 -6.56227933 -0.33947606 0.42941903 4.06722991

-2.51589676 3.59154152 -0.56854266 4.80755935 -4.40211945 -4.48899094

2.35496049 4.29372575 -1.31098376 3.58694409 -1.27049946 -6.92633096

-0.51874196 2.27321339 -2.39942411 -2.85627873 2.22191348 -0.09484893

2.80155451 -1.94422791 6.60358395]] in n\_iterations: 10

**การทดลองที่ 1** : การทดลองเปลี่ยนโครงสร้างของ Multilayer perceptron (Hidden layer , layer )

* n\_iterations = 10
* n\_particles = 10
* c1 = 1.2
* c2 = 1.4
* W = (1/2\*(c1+c2))+0.3

**ผลการทดลองที่ 1 :**

|  |  |  |  |
| --- | --- | --- | --- |
| **Hidden layer 1** | **Hidden layer 2** | **Iteration** | **g\_best** |
| 2 | - | 1 | 18.00538808163395 |
| 2 | - | 2 | 17.96673232352557 |
| 2 | - | 3 | 17.858448629453253 |
| 2 | - | 4 | 17.78552325481207 |
| 2 | - | 5 | 17.738549751496265 |
| 2 | - | 6 | 17.700776583774577 |
| 2 | - | 7 | 17.679119158730977 |
| 2 | - | 8 | 17.662886643907438 |
| 2 | - | 9 | 17.655702495749974 |
| 2 | - | 10 | 17.651988418649502 |
| 5 | - | 1 | 17.823811493579896 |
| 5 | - | 2 | 17.78913476654413 |
| 5 | - | 3 | 17.70865358396295 |
| 5 | - | 4 | 17.66471859913042 |
| 5 | - | 5 | 17.653171075858634 |
| 5 | - | 6 | 17.644398586378543 |
| 5 | - | 7 | 17.6421927783463 |
| 5 | - | 8 | 17.6421927783463 |
| 5 | - | 9 | 17.641601851558804 |
| 5 | - | 10 | 17.64110692835963 |
| **Hidden layer 1** | **Hidden layer 2** | **Iteration** | **g\_best** |
| 8 | - | 1 | 17.766007684068132 |
| 8 | - | 2 | 17.717723205036812 |
| 8 | - | 3 | 17.655033565101213 |
| 8 | - | 4 | 17.64578428155221 |
| 8 | - | 5 | 17.642840108152157 |
| 8 | - | 6 | 17.641534234929104 |
| 8 | - | 7 | 17.641097932007295 |
| 8 | - | 8 | 17.6410342196003 |
| 8 | - | 9 | 17.641030042998697 |
| 8 | - | 10 | 17.641030042998697 |
| 10 | - | 1 | 17.802974836545012 |
| 10 | - | 2 | 17.802974836545012 |
| 10 | - | 3 | 17.724769950930142 |
| 10 | - | 4 | 17.676149796752902 |
| 10 | - | 5 | 17.672371561226928 |
| 10 | - | 6 | 17.669352181894578 |
| 10 | - | 7 | 17.65795087875403 |
| 10 | - | 8 | 17.656054019922937 |
| 10 | - | 9 | 17.649052812285742 |
| 10 | - | 10 | 17.649052812285742 |
| 15 | - | 1 | 17.784751803977244 |
| 15 | - | 2 | 17.71559665807288 |
| 15 | - | 3 | 17.650841983637875 |
| 15 | - | 4 | 17.645179282655388 |
| 15 | - | 5 | 17.64160864530061 |
| 15 | - | 6 | 17.64103938817289 |
| 15 | - | 7 | 17.640941559503034 |
| 15 | - | 8 | 17.640941559503034 |
| 15 | - | 9 | 17.640930909403927 |
| **Hidden layer 1** | **Hidden layer 2** | **Iteration** | **g\_best** |
| 15 | - | 10 | 17.640930909403927 |
| 2 | 5 | 1 | 18.058831063060513 |
| 2 | 5 | 2 | 18.01922321936464 |
| 2 | 5 | 3 | 17.858889341265776 |
| 2 | 5 | 4 | 17.746312933587202 |
| 2 | 5 | 5 | 17.687030831694777 |
| 2 | 5 | 6 | 17.65659620149382 |
| 2 | 5 | 7 | 17.646321769548717 |
| 2 | 5 | 8 | 17.643148189386654 |
| 2 | 5 | 9 | 17.641611322089393 |
| 2 | 5 | 10 | 17.641179228680873 |
| 7 | 8 | 1 | 17.825502021577968 |
| 7 | 8 | 2 | 17.78404785133928 |
| 7 | 8 | 3 | 17.676309386194244 |
| 7 | 8 | 4 | 17.646153666583157 |
| 7 | 8 | 5 | 17.641922748320976 |
| 7 | 8 | 6 | 17.641012167968768 |
| 7 | 8 | 7 | 17.640903850869172 |
| 7 | 8 | 8 | 17.640893999473544 |
| 7 | 8 | 9 | 17.640892721209884 |
| 7 | 8 | 10 | 17.64089252833696 |
| 15 | 15 | 1 | 17.768882630571635 |
| 15 | 15 | 2 | 17.69548655948311 |
| 15 | 15 | 3 | 17.643385150940006 |
| 15 | 15 | 4 | 17.6409981167713 |
| 15 | 15 | 5 | 17.640899625084074 |
| 15 | 15 | 6 | 17.640892572449804 |
| 15 | 15 | 7 | 17.64089251919279 |
| 15 | 15 | 8 | 17.640892519002808 |
| **Hidden layer 1** | **Hidden layer 2** | **Iteration** | **g\_best** |
| 15 | 15 | 9 | 17.640892518999063 |
| 15 | 15 | 10 | 17.64089251899905 |

**วิเคราะห์ผลการทดลองที่ 1** :

จะเห็นว่าการเพิ่มของจำนวน Node ใน Hidden layer นั้นมีผล ดูจากในช่วงต้องตารางจะเห็นว่า กรณีที่มีจำนวนของ Hidden layer น้อยนั้นจะส่งผลให้มีจำนวน error average มากกว่า ส่วนที่มีจำนวน Hidden layer มากกว่าใน ขั้นต่อ ๆมา แต่ในกรณีของการเพิ่ม Hidden layer กลับไม่ส่งผลมากแต่เป้นการส่งผลเพียงเล็กน้อยถึงอาจหมายถึงไม่ส่งผลต่อการลด error average เลย โดยดูจากในช่วง Hidden layer 1 = 2 , Hidden layer 2 = 5 ในช่วง iteration แรกๆนั้นจะมีค่ามากพอๆกันหรือมากกว่า กรณีที่เป็น Hidden layer 1 = 2 เพียงตัวเดียว แต่ ในช่วงปลายของ Hidden layer 1 = 15 และ Hidden layer 2 = 15 กลับทำผลเฉลี่ยออกมาได้ดีที่สุด จึงไม่สามารถสรุปได้ว่า Hidden layer นั้นมีผลต่อการลดค่า error average

**การทดลองที่ 2** : การทดลองเพิ่ม-ลด ค่า c1 และ c2

* n\_iterations = 10
* n\_particles = 10
* Structure [8,10,1]
* W = (1/2\*(c1+c2))+0.3

**ผลการทดลองที่ 2 :**

|  |  |  |
| --- | --- | --- |
| **c1** | **c2** | **g\_best** |
| 0.25 | 1 | 17.82574999578676 |
| 0.5 | 1 | 17.69416106438929 |
| 1.0 | 1 | 17.675853235605697 |
| 1.25 | 1 | 17.66943391464948 |
| 1 | 0.25 | 17.910591700107478 |
| 1 | 0.5 | 17.70798841571437 |
| 1 | 1.25 | 17.661233477078124 |

**วิเคราะห์ผลการทดลองที่ 2** :

จะเห็นว่าการเพิ่มค่า c1 และ c2 นั้นส่งผลต่อค่า g\_best ซึ่งในผลจะออกมาว่า ยิ่งเพิ่มค่า c1 และ c2 จะยิ่งทำให้ได้ค่า g\_best ที่มีค่าดีมากขึ้น แต่ก็เป็นผลเสียเช่นกันเนื่องจากการใช้ค่า c1 และ c2 ที่มากเกิน อาจส่งผลให้เกิดการลู่เข้าสู่ local min ซึ่งจะทำให้ไม่สามารถปรับเปลี่ยนค่า position ได้อีก ซึ่งเป็นผลเสียทำให้ไม่เกิดการพัฒนาใน Model แต่ถ้าเราใช้ c1 และ c2 ให้เหมาะมก็จะเป็นผลดีต่อการ train เพราะจะทำให้การเคลื่อนที่ของ particles เป็นไปอย่างถูกต้องและรวดเร็วมากขึ้น

**การทดลองที่ 3** : การทดลองเพิ่ม-ลด n\_iterations และ n\_particles

* c1 = 1.2
* c2 = 1.4
* W = (1/2\*(c1+c2))+0.3
* Structure [8,10,1]

**ผลการทดลองที่ 3 :**

|  |  |  |
| --- | --- | --- |
| **iterations** | **n\_particles** | **g\_best** |
| 1 | 10 | 17.739292470608223 |
| 2 | 10 | 17.732525646928245 |
| 5 | 10 | 17.731915745072357 |
| 10 | 10 | 17.731721853165986 |
| 10 | 1 | 18.038970783198774 |
| 10 | 2 | 17.67881157595578 |
| 10 | 5 | 17.673519929071404 |
| 10 | 10 | 17.64251391417346 |

**วิเคราะห์ผลการทดลองที่ 3** :

จะเห็นว่าในการเพิ่มหรือลด iterations หรือ particles นั้นมีผลต่อการเปลี่ยนแปลงของค่า g\_best ซึ่งยิ่งมีค่า iterations และ n\_particles มากก็จะยิ่งทำให้ได้ค่า g\_best ดีมากขึ้น โดยการเพิ่มจำนวนของ particles ดูจะส่งผลต่อค่า g\_best มากกว่า กรณีของ การเพิ่ม iterations แต่ในที่นี้ ผลอาจเกิดการผิดพลาดได้เพราะ อาจจะเกี่ยวข้องกับการสุ่ม position ของ particles ในตอนแรก ซึ่ง ตำแหน่งอาจจะไปอยู่ใกล้กับตำแหน่งที่ดีที่สุดก็ได้

**Code :**

1. **import** numpy **as** np
2. **import** random
3. **import** pdb
4. **import** pandas **as** pd
6. dataset = pd.read\_excel('./AirQualityUCI.xlsx')
7. columns = dataset.columns
9. data\_ip = dataset[[columns[3],columns[6],columns[8],columns[10],columns[11],columns[12],columns[13],columns[14]]]
10. desire\_op = dataset[[columns[5]]]
12. **class** Particle():
13. **def** \_\_init\_\_(self,layer):
14. self.layer = []
15. self.velocity = []
16. self.weightmin = -1
17. self.weightmax = 1
18. self.fitness = 0
19. self.position = []
20. self.getweight(layer)
21. self.pbest\_position = self.position
22. self.pbest\_value = float('inf')

25. **def** getweight(self,layer):
26. self.layer = layer
27. chromolen = 0
29. **for** i **in** range(1,len(layer)):
30. chromolen = chromolen +  (layer[i-1]\*layer[i])
31. self.velocity = np.zeros(chromolen)
32. *#         print(self.velocity)*
34. gene = np.zeros(chromolen)
35. **for** j **in** range(len(gene)):
36. gene[j] = self.weightmin + (self.weightmax - self.weightmin)\*random.random()
37. self.position.append(gene)
39. **def** move(self):
40. self.position = self.position + self.velocity
42. **class** Space():
44. **def** \_\_init\_\_(self, target, n\_particles,train\_ip,train\_op,layer):
45. self.target = target
46. self.n\_particles = n\_particles
47. self.particles = []
48. self.gbest\_value = float('inf')
49. self.weightmin = -1
50. self.weightmax = 1
51. self.layer = layer
52. self.gbest\_position = []
53. self.get\_gbest(self.layer)
54. self.train\_i = train\_ip
55. self.train\_o = train\_op
57. *#         print(self.gbest\_position)*
59. **def** get\_gbest(self,layer):
60. chromolen = 0
62. **for** i **in** range(1,len(layer)):
63. chromolen = chromolen +  (layer[i-1]\*layer[i])
65. gene = np.zeros(chromolen)
66. **for** j **in** range(len(gene)):
67. gene[j] = self.weightmin + (self.weightmax - self.weightmin)\*random.random()
68. self.pogbest\_positionsition = gene
70. **def** set\_pbest(self):
71. **for** particle **in** self.particles:
72. *#             print(particle.position)*
73. self.computefitness(particle)
74. *#             print(particle.fitness)*
75. *#             fitness\_cadidate = self.fitness(particle)*
76. **if**(particle.pbest\_value > particle.fitness):
77. particle.pbest\_value = particle.fitness
78. particle.pbest\_position = particle.position
79. **print**('----> pbest : ',particle.pbest\_value)
81. **def** set\_gbest(self):
82. **for** particle **in** self.particles:
83. self.computefitness(particle)
84. *#             best\_fitness\_cadidate = self.fitness(particle)*
85. *#             print(particle.fitness)*
86. **if**(self.gbest\_value > particle.fitness):
87. self.gbest\_value = particle.fitness
88. self.gbest\_position = particle.position
90. **def** move\_particles(self):
91. **for** particle **in** self.particles:
92. **global** W
93. *#             pdb.set\_trace()*
94. new\_velocity = (W\*particle.velocity)  + (c1\*random.random()) \* (np.array(particle.pbest\_position) - np.array(particle.position)) + (random.random()\*c2) \* (np.array(self.gbest\_position) - np.array(particle.position))
95. particle.velocity = new\_velocity
96. particle.move()
98. **def** computefitness(self,particle):
99. mlp = MLP(self.layer)
100. mlp.initweight(particle.position)
101. particle.fitness = 0
102. **for** i **in** range(len(self.train\_i)) :
103. error = mlp.forward(self.train\_i.iloc[i],self.train\_o.iloc[i])
104. particle.fitness += error
105. particle.fitness = particle.fitness/len(self.train\_i)
106. *#         print(chomosome.fitness)*

109. **class** MLP:
110. **def** \_\_init\_\_(self,structure\_layer):
111. self.maxNode = 0
112. self.structure = structure\_layer
114. **for** i **in** structure\_layer:
115. **if** self.maxNode < i :
116. self.maxNode = i
118. self.weight = np.zeros((len(structure\_layer)-1,self.maxNode,self.maxNode))
119. *#         print(self.weight)*
121. **def** initweight(self,chomosome):
122. count = 0
123. *#         print(self.weight)*
124. **for** i **in** range(len(self.structure)-1):
125. **for** j **in** range(self.structure[i]):
126. **for** k **in** range(self.structure[i+1]):
127. *#                     print(chomosome.position[count])*
128. *#                     print(chomosome[count])*
129. self.weight[i][j][k] = chomosome[0][count]
130. count = count+1
132. **def** forward(self,data,op):
133. y = np.zeros((len(self.structure),self.maxNode))
134. *#         print(list(data.values())[2:])*
135. **for** i **in** range(len(data.values)):
136. y[0][i] = data.values[i]
137. **for** i **in** range(1,len(self.structure)):
138. **for** j **in** range(self.structure[i]):
139. v = 0
140. **for** k **in** range(self.structure[i-1]):
141. v = v + y[i-1][k]\*self.weight[i-1][k][j]
142. y[i][j] = self.sigmoid(v)
143. *#         print(abs(op.values-y[len(self.structure)-1][0]))*
144. **return** abs(op.values-y[len(self.structure)-1][0])
146. **def** sigmoid(self,v):
147. **return** 1/(1+np.exp(-v))
149. c1 = 1.2
150. c2 = 1.4
151. W = (1/2\*(c1+c2)-1)+0.3
153. n\_iterations = 10
154. n\_particles = 10
155. structure = [8,15,1]
157. **for** c **in** range(10):
158. **print**("------------------------- # Round "+str(c)+' ------------------------- ')
159. i = int(c\*len(data\_ip)\*0.1)
160. test\_ip = data\_ip[i:int(i+int(len(data\_ip)\*0.1))]
161. test\_op = desire\_op[i:int(i+int(len(data\_ip)\*0.1))]
162. train\_ip = data\_ip.drop(data\_ip.index[i:i+int(len(data\_ip)\*0.1)])
163. train\_ip = desire\_op.drop(desire\_op.index[i:i+int(len(data\_ip)\*0.1)])
165. particles\_vector = []
166. search\_space = Space(1, n\_particles,train\_ip,desire\_op,structure)
167. particles\_vector = [Particle(structure) **for** \_ **in** range(search\_space.n\_particles)]
168. search\_space.particles = particles\_vector
169. iteration = 0
170. **while**(iteration < n\_iterations):
171. **print**("iteration : #"+str(iteration+1))
172. search\_space.set\_pbest()
173. search\_space.set\_gbest()
174. search\_space.move\_particles()
175. iteration += 1
176. **print**("-----> gbest : ", search\_space.gbest\_value[0])
178. **print**("The best solution is: ", search\_space.gbest\_position, " in n\_iterations: ", iteration)