IM39003

Assignment 6: *Particle Swarm Optimization*

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ACTIVITY 1

This section summarizes the results of experiments conducted to study the effect of change in various parameters on the convergence of the Particle Swarm Optimization

We have the following objective function :

$$z = 10(x_1-1)^2 + 20(x_2-1)^2 + 30(x_3-1)^2$$

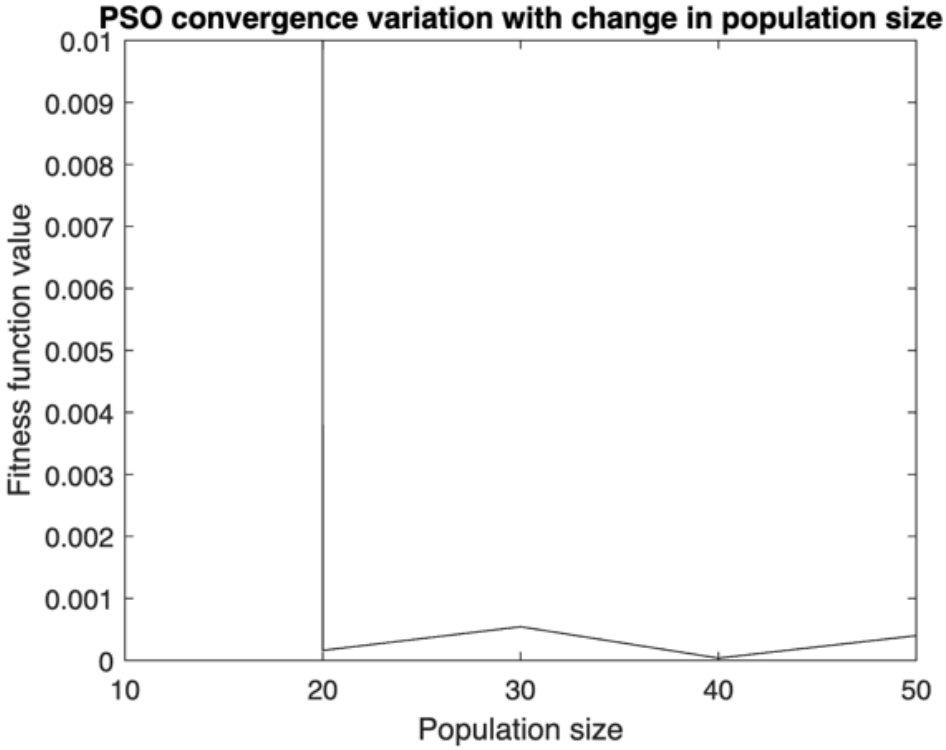
1) Change # of population size: 10,20,...50
2) Change inertia weight(W) : 0.1, ---,0.9
3) Change the # of iteration :10:10:100
4) Change the acceleration factor
   a) C1 (for Pbest) 0:0.2:1
   b) C2 (for Gbest) 0:0.2:1
5) Comment on what will happened when C1>C2 and C2>C1
6) Comment on whether run has any effect

Default set of parameters :

```
n=100;          % population size
w= 0.1          % inertia weight
wdamp = 0.99    % inertia deamping
c1=1;           % acceleration factor P_best
c2=2;           % acceleration factor G_best
maxite=10;      % set maximum number of iteration in each run
maxrun=1;       % set maximum number of runs need to be
```

1. Change in population size

Population size	Optimal value obtained	x1	x2	x3
10	11.4815	1.6606	2.0201	2.5132
20	0.0002	0.9981	1.999	3.0019
30	0.0005	0.9945	2.0015	2.9975
490	0	1.0004	1.9987	3.0001
50	0.0004	0.9974	2	3.0033



Best value obtained at population size = 40

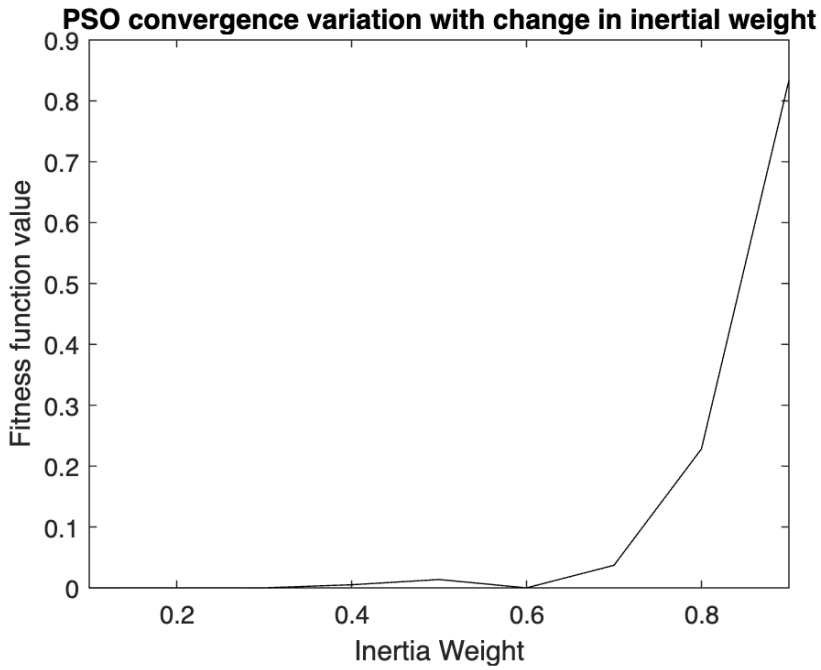
2. Change in Inertia Weight

Optimal values corresponding to inertia weight = {0.1…0.9}

0.0000
0.0002
0.0001
0.0051
0.0137
0.0000
0.0371
0.2283
0.8337

X values corresponding to inertia weight = {0.1…0.9}

1.0000	2.0008	3.0008
0.9984	2.0016	2.9977
0.9987	2.0013	3.0005
0.9874	2.0085	3.0083
1.0254	2.0021	2.9845
1.0000	2.0000	3.0000
0.9397	2.0056	3.0020
0.9631	1.9644	2.9206
0.7564	2.0967	2.9579



Best value obtained at 0.1 and 0.6

3. Change in Maximum Iterations

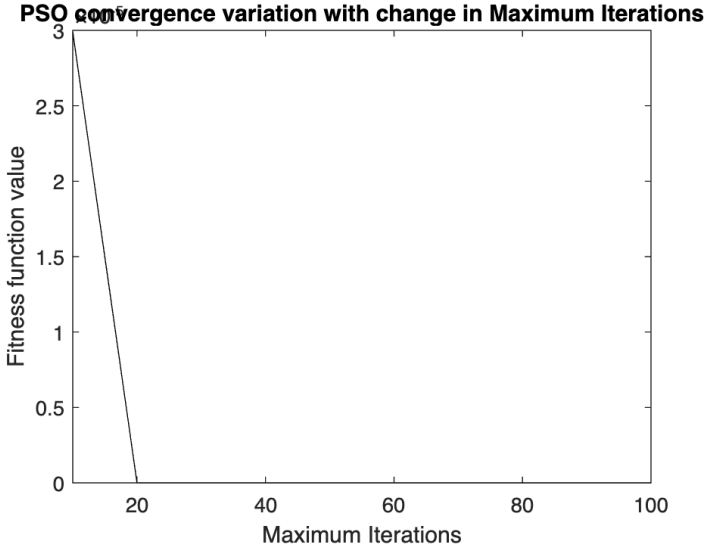
Optimal values corresponding to Max Iter= {10,20…1000}

multiplication factor for the below values = 1.0e-04

0.2990	0.0000	0.0000	0.0000	0	0	0	0	0	0

X values corresponding to Max Iter = {10,20…100}

1.0000	2.0008	3.0008
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000



Best value obtained for max iterations >= 20

4. Change in C1 & C2

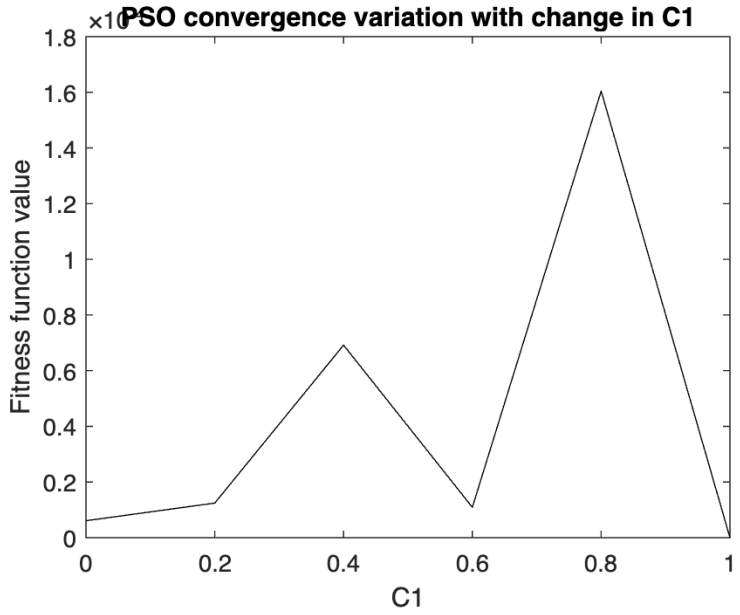
multiplication factor for the below values = 1.0e-03

Optimal values corresponding to C1= {0,0.2…1}

0.0061	0.0124	0.0692	0.0109	0.1604	0

X values corresponding to C1= {0,0.2…1}

1.0004	2.0005	2.9999
0.9995	1.9993	3.0002
0.9997	1.9998	2.9985
1.0005	1.9995	2.9997
1.0011	1.9996	2.9978
1.0000	2.0000	3.0000



Best value at C1 = 1.0

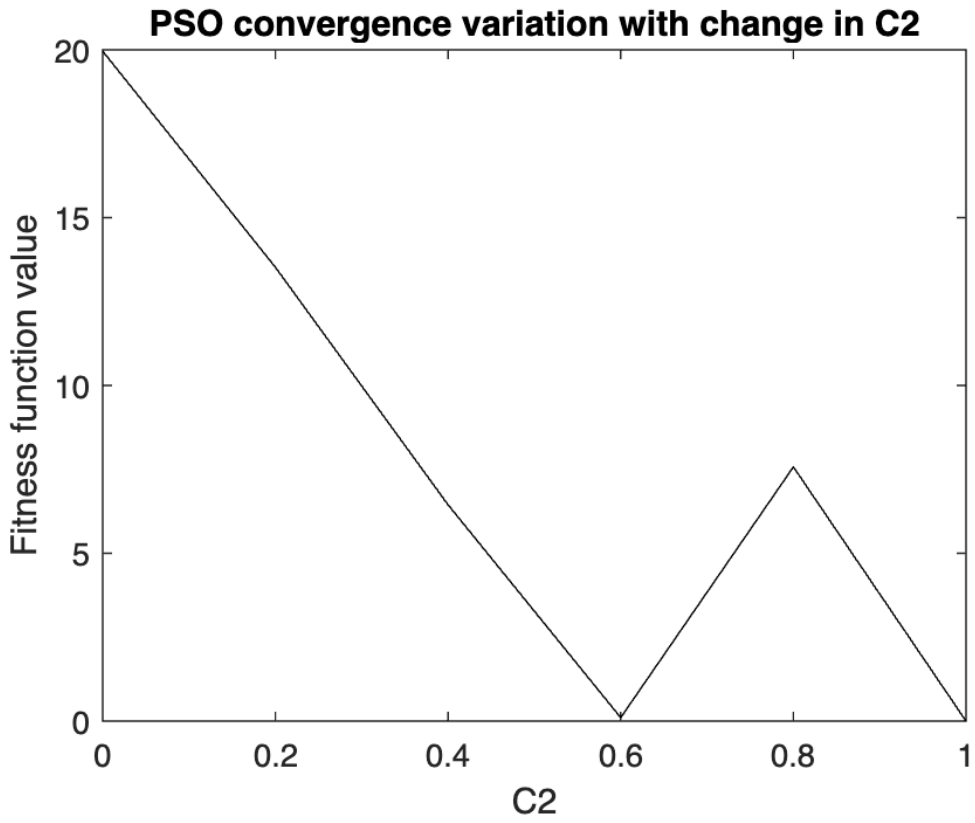
Similarly C2 was varied and best value was obtained at C2=1.0

c2_variations =

19.9587 13.5217 6.4449 0.1034 7.5726 0

c2_variations_X =

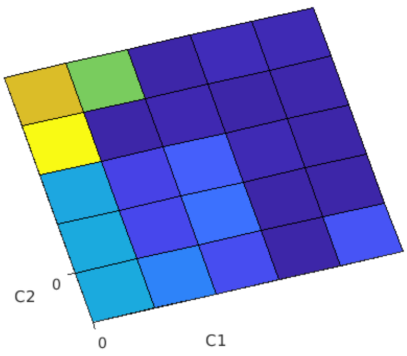
0.9997	2.9990	2.9985
1.5185	1.3849	2.6700
1.7616	2.1759	2.9710
1.0997	1.9950	3.0109
1.7887	2.1945	3.1409
1.0000	2.0000	3.0000



But it was observed that the best value of optimal varies differently when c1 and c2 are both varied

c12_variations =

20.0000	13.7961	6.5244	0.1079	7.5726	0
20.0000	5.6861	11.5016	0.0419	0.0106	0.0002
19.5972	5.0001	9.0161	0.7954	0	0.0000
50.0000	0	0.7178	0.0061	0.2454	0.0000
38.7072	32.8401	0.1538	1.2665	0.8785	0.0009
29.9329	3.4255	0	0.2773	0.0000	0.0001



Purple indicates low value, yellow indicates highest

pairs of (c1,c2) that gave the optimal value :

(0,1) , (0.4,0.8), (0.6,0.2), (1,0.4)

THERE IS BETTER CONVERGENCE WHEN C2>C1 AS SEEN FROM THE MESH PLOT (Answer to Q5)

5. Change in Maximum Runs

maxrun_variations =

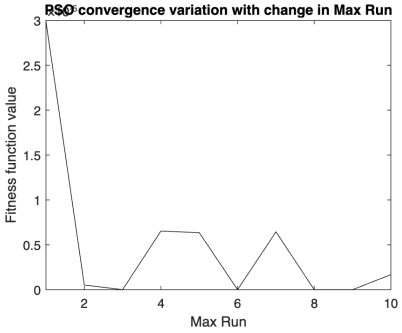
multiplication factor for the below values = 1.0e-04

Optimal values corresponding to max run= {1,2..10}

0.2990	0.0052	0	0.0653	0.0635	0	0.0644	0	0	0.0168

X values corresponding to max run= {1,2..10}

1.0000	2.0008	3.0008
1.0000	2.0001	3.0000
1.0000	2.0000	3.0000
1.0005	1.9996	3.0001
0.9994	1.9999	2.9997
1.0000	2.0000	3.0000
1.0005	1.9995	3.0001
1.0000	2.0000	3.0000
1.0000	2.0000	3.0000
1.0003	1.9999	2.9998



There was no prominent trend observed when max runs was varied (Question 6)

We now have the following constraints :

1) $x_1 + x_2 + x_3 \leq 5$
2) $x_1^2 + 2x_2 - x_3 \leq 0$

Adding penalty to fitness value :

```
function p = penalty(x)

    p=0;
    M = 1000;

% constraint 1
    c1 = x(1)+x(2)+x(3)-5;
    if c1<=0
        p = p+0;
    else
        p = p+ M*c1;

    end
% constraint 2
    c2 = x(1).^2 + (2*x(2)) - x(3);
    if c2<=0
        p = p+0;
    else
        p = p+ M*c2;

    end

end
```

```
function f=ofun(x)

%objective function (minimization)


of=10*(x(1)-1)^2+20*(x(2)-2)^2+30*(x(3)-3)^2;
of = of+penalty(x);

f=of;
```

BEST PARAMETERS :

```
%%PSO Parsms : BEST FROM ACTIVITY 1
    n=40;          % population size
    w= 0.6;          % inertia weight
    wdamp = 0.99;    % inertia deamping
    c1=0.4;           % acceleration factor P_best
    c2=0.8;           % acceleration factor G_best
    maxite=100;      % set maximum number of iteration in each run
    maxrun=9;       % set maximum number of runs need to be


[solution,best_variables,bestrun,ffite,ffmin] = PSO(n,w,wdamp,c1,c2,maxite,maxrun);


% PSO convergence characteristic
plot(ffmin(1:ffite(bestrun),bestrun),'-k');
xlabel('Iteration');
ylabel('Fitness function value (objective + penalty');
title('PSO convergence characteristic')
```

RESULT OBTAINED

```
bestfun =

   10.0327


bestrun =

     2


best_variables =

    0.3074    1.5053    3.1065
```

The optimal value when the constraints are included is ~ 10