

```

function
[X1,Y1,X2,Y2,E_fly,E_fly1]=DA_final(SearchAgents_no,Max_iteration,lb,u
b,dim,X1,Y1,lb1,ub1,dim1,X2,Y2)

X_old=X1;
Y_old=Y1;

BS_X=50;
BS_Y=50;

display('DA is optimizing problem');
cg_curve=zeros(1,Max_iteration);

if size(ub,2)==1
    ub=ones(1,dim)*ub;
    lb=ones(1,dim)*lb;
end

r1=(ub-lb)/10;
R=20;

Delta_Xmax1=2; %(ub-lb)/10;
Delta_Ymax2=2; %(ub-lb)/10;

E_fly1=zeros(Max_iteration,SearchAgents_no);
N_Pair=zeros(1,Max_iteration);

Food_fitnessX1=inf;
Food_fitnessY1=inf;

Food_posX1=zeros(dim,1);
Food_posY1=zeros(dim,1);

Food_pos1=zeros(2,Max_iteration);
Enemy_fitnessX1=-inf;
Enemy_fitnessY1=-inf;

Enemy_posX1=zeros(dim,1);
Enemy_posY1=zeros(dim,1);
Fitness1=zeros(2,SearchAgents_no);

DeltaX1=rand(1,SearchAgents_no);
DeltaY1=rand(1,SearchAgents_no);

neighbours_no=0;
Separation = zeros(2,SearchAgents_no,Max_iteration);
cnt_isolated=zeros(SearchAgents_no,Max_iteration);
cnt=zeros(1,Max_iteration);

for iter=1:Max_iteration

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old_X=X1;
old_Y=Y1;

    for i=1:SearchAgents_no
    for j=1:SearchAgents_no
        All_dist2(i,j,iter)=sqrt((X1(i)-X1(j))^2+(Y1(i)-Y1(j))^2);
    end
    end

    cnt(iter)=0;

for i=1:SearchAgents_no
    for j=1:SearchAgents_no

        if(All_dist2(i,j,iter)>R )
            cnt_isolated(i,iter)=cnt_isolated(i,iter)+1;
        end
    end
end

for i=1:SearchAgents_no

    N_no(iter,i)=SearchAgents_no-cnt_isolated(i,iter)-1;

    if(cnt_isolated(i,iter)==SearchAgents_no-1)

        cnt(iter)=cnt(iter)+1;
        N_isolated(iter,cnt(iter))=i;
    end
end

for i=1:SearchAgents_no
    dist_BS(i)=sqrt((BS_X-X1(i))^2+(BS_Y-Y1(i))^2);
end

r1=(ub-lb)/4+((ub-lb)*(iter/Max_iteration)*2);
w1=0.9-iter*((0.9-0.4)/Max_iteration);
my_c=0.1-iter*((0.1-0)/(Max_iteration/2));

if my_c<0
    my_c=1;
end

s1=2*rand*my_c;
a1=2*rand*my_c;
c1=2*rand*my_c;
f1=2*rand;
e1=my_c;

for i=1:SearchAgents_no

    if(i~=SearchAgents_no)

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        Fitness1(1,i)=(N_no(iter,i))+E_fly1(iter,i)/(BS_X-
X1(i))^2;
        Fitness1(2,i)=(N_no(iter,i))+E_fly1(iter,i)/(BS_Y-
Y1(i))^2;
        F_Fitness(iter,i)=sqrt(Fitness1(1,i)^2+Fitness1(2,i)^2);
    end

    if Fitness1(1,i)<Food_fitnessX1
        Food_fitnessX1=Fitness1(1,i);
        Food_posX1=X1(:,i);
    end

    if Fitness1(2,i)<Food_fitnessY1
        Food_fitnessY1=Fitness1(2,i);
        Food_posY1=Y1(:,i);
    end

    if Fitness1(1,i)>Enemy_fitnessX1
        if (all(X1(:,i)<ub') && all(X1(:,i)>lb'))
            Enemy_fitnessX1=Fitness1(1,i);
            Enemy_posX1=X1(:,i);
        end
    end

    if Fitness1(2,i)>Enemy_fitnessY1
        if (all(Y1(:,i)<ub') && all(Y1(:,i)>lb'))
            Enemy_fitnessY1=Fitness1(2,i);
            Enemy_posY1=Y1(:,i);
        end
    end

end

for i=1:SearchAgents_no
    for j=1:SearchAgents_no
        All_dist(i,j,iter)=sqrt((X1(i)-X1(j))^2+(Y1(i)-Y1(j))^2);
    end

    index=0;
    neighbours_no=0;

    for j=1:SearchAgents_no
        Dist2Enemy=sqrt((X1(i)-X1(j))^2+(Y1(i)-Y1(j))^2);

        if (all(Dist2Enemy<R) && all(Dist2Enemy~=0))
            index=index+1;
            neighbours_no=neighbours_no+1;
            Neighbours_DeltaX(:,index)=DeltaX1(:,j);
            Neighbours_X(:,index)=X1(:,j);
            Neighbours_DeltaY(:,index)=DeltaY1(:,j);
            Neighbours_Y(:,index)=Y1(:,j);
        end
    end
end
end

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```

Nbn(iter,i)=neighbours_no;

%
Seperation%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Eq. (1)
S_X1=0;
S_Y1=0;

if(N_no(iter,i)>1)
    for k=1:N_no(iter,i)
        N_dist(i,k,iter)=sqrt((Neighbours_X(k)-
X1(i))^2+(Neighbours_Y(k)-Y1(i))^2);
        S_X1=S_X1+(Neighbours_X(k)-X1(i));
        S_Y1=S_Y1+(Neighbours_Y(k)-Y1(i));
    end
    S_X1=-S_X1;
    S_Y1=-S_Y1;
else
    S_X1=0;
    S_Y1=0;
end

% Alignment%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Eq. (2)
A_X1=0;
A_Y1=0;

if N_no(iter,i)>1
    for k=1:N_no(iter,i)
        A_X1=(sum(Neighbours_DeltaX'))/N_no(iter,i);
        A_Y1=(sum(Neighbours_DeltaY'))/N_no(iter,i);
    end
else
    A_X1=0;
    A_Y1=0;
end

% Cohesion%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Eq. (3)
C_tempX1=0;
C_tempY1=0;

if N_no(iter,i)>1
    for k=1:N_no(iter,i)
        C_tempX1=(sum(Neighbours_X'))/N_no(iter,i);
        C_tempY1=(sum(Neighbours_Y'))/N_no(iter,i);
    end
else
    C_tempX1=0;
    C_tempY1=0;
end
end

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C_X1=C_tempX1;
C_Y1=C_tempY1;

% Attraction to food%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Eq. (4)
Dist2Food=sqrt((X1(i)-Food_posX1(:,1))^2+(Y1(i)-
Food_posY1(:,1))^2);

if all(Dist2Food<=R)
    F1=sqrt((Food_posX1(:,1)-X1(:,i))^2+(Food_posY1(:,1)-
Y1(:,i))^2);
else
    F1=0;
end

% Distraction from enemy%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Eq. (5)
Dist2Enemy=sqrt((X1(:,i)-Enemy_posX1(:,1))^2+(Y1(:,i)-
Enemy_posY1(:,1))^2);
if all(Dist2Enemy<=R)
    Enemy_X1=Enemy_posX1+X1(:,i);%+Separation(1,i,iter);
    Enemy_Y1=Enemy_posY1+Y1(:,i);%+Separation(2,i,iter);
else
    Enemy_X1=0;
    Enemy_Y1=0;
end

if X1(i)>ub
    X1(i)=lb;
    DeltaX1(i)=rand;
end
if X1(i)<lb
    X1(i)=ub;
    DeltaX1(i)=rand;
end

if Y1(i)>ub
    Y1(i)=lb;
    DeltaY1(i)=rand;
end

if Y1(i)<lb
    Y1(i)=ub;
    DeltaY1(i)=rand;
end

if any(Dist2Food>R)

    if N_no(iter,i)>1
        DeltaX1(i)=w1*DeltaX1(i)+rand*A_X1+rand*C_X1+rand*S_X1;
    end
end

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        if DeltaX1(i)>Delta_Xmax1
            DeltaX1(i)=Delta_Xmax1;
        end

        if DeltaX1(i)< -Delta_Xmax1
            DeltaX1(i)=-Delta_Xmax1;
        end

        X1(i)=X1(i)+DeltaX1(i)/N_no(iter,i);

DeltaY1(i)=w1*DeltaY1(i)+rand*A_Y1+rand*C_Y1+rand*S_Y1;

        if DeltaY1(i)>Delta_Ymax2
            DeltaY1(i)=Delta_Ymax2;
        end

        if DeltaY1(i)< -Delta_Ymax2
            DeltaY1(i)=-Delta_Ymax2;
        end

        Y1(i)=Y1(i)+DeltaY1(i)/N_no(iter,i);
    else

        % Eq. (8)
        dim=1;
        X1(i)=X1(i)+Levy(dim)' .*X1(i);
        DeltaX1(i)=0;

        Y1(i)=Y1(i)+Levy(dim)' .*Y1(i);
        DeltaY1(i)=0;

    end
else

    % Eq. (6)

DeltaX1(i)=(a1*A_X1+c1*C_X1+s1*S_X1+f1*F1+e1*Enemy_X1)+ w1*DeltaX1(i);

        if DeltaX1(i)>Delta_Xmax1
            DeltaX1(i)=Delta_Xmax1;
        end

        if DeltaX1(i)< -Delta_Xmax1
            DeltaX1(i)=-Delta_Xmax1;
        end

        X1(i)=X1(i)+DeltaX1(i);

DeltaY1(i)=(a1*A_Y1+c1*C_Y1+s1*S_Y1+f1*F1+e1*Enemy_Y1)+ w1*DeltaY1(i);

        if DeltaY1(i)>Delta_Ymax2
            DeltaY1(i)=Delta_Ymax2;

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        end

        if DeltaY1(i)< -Delta_Ymax2
            DeltaY1(i)=-Delta_Ymax2;
        end

        Y1(i)=Y1(i)+DeltaY1(i);
    end

    Flag4ub_X=X1(i)>ub';
    Flag4lb_X=X1(i)<lb';

X1(i)=(X1(i).*(~(Flag4ub_X+Flag4lb_X)))+ub'.*Flag4ub_X+lb'.*Flag4lb_X;
    Flag4ub_Y=Y1(i)>ub';
    Flag4lb_Y=Y1(i)<lb';

Y1(i)=(Y1(i).*(~(Flag4ub_Y+Flag4lb_Y)))+ub'.*Flag4ub_Y+lb'.*Flag4lb_Y;
    flag_n(i)=0;

    if(neighbours_no>=2)
        flag_n(i)=1;
    end

    if(N_no(iter,i)==1)
        N_Pair(iter)=N_Pair(iter)+1;
    end

    E_fly1(iter,i)=(old_X(i)-X1(i))^2+(old_Y(i)-Y1(i))^2;
end

if(cnt(iter)==0)
    break;
end

Best_score1=Food_fitnessX1;
Best_posX1=Food_posX1;
Best_posY1=Food_posY1;
cg_curve(iter)=Best_score1;

clf(figure(2))
for i=1:SearchAgents_no;
figure(2)
hold on
plot(X1(i),Y1(i),'o')
text(X1(i),Y1(i),num2str(i))
plot(BS_X,BS_Y,'X')
xlabel('Distance (meter)','FontSize',10);
ylabel('Altitude (meter)','FontSize',10);
end
title('Final Network after DA')

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    WAIT=0.5;
    pause(WAIT/5);
end

X_old1=X2;
Y_old1=Y2;

BS_X1=50;
BS_Y1=50;

cg_curve=zeros(1,Max_iteration);

if size(ub1,2)==1

    ub1=ones(1,dim1)*ub1;
    lb1=ones(1,dim1)*lb1;

end

r1=(ub1-lb1)/10;
R1=20;

Delta_Xmax1=rand;
Delta_Ymax1=rand;

E_fly=zeros(Max_iteration,SearchAgents_no);
N_Pair1=zeros(1,Max_iteration);

Food_fitnessX1=inf;
Food_fitnessY1=inf;

Food_posX1=zeros(dim1,1);
Food_posY1=zeros(dim1,1);

Food_pos1=zeros(2,Max_iteration);

Enemy_fitnessX1=-inf;
Enemy_fitnessY1=-inf;

Enemy_posX1=zeros(dim1,1);
Enemy_posY1=zeros(dim1,1);

Fitness1=zeros(2,SearchAgents_no);

DeltaX1=rand(1,SearchAgents_no);
DeltaY1=rand(1,SearchAgents_no);

neighbours_no=0;

Separation = zeros(2,SearchAgents_no,Max_iteration);
cnt_isolated1=zeros(SearchAgents_no,Max_iteration);
cnt1=zeros(1,Max_iteration);

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for iter=1:Max_iteration

old_X1=X2;
old_Y1=Y2;

for i=1:SearchAgents_no

    for j=1:SearchAgents_no

        All_dist2(i,j,iter)=sqrt((X2(i)-X2(j))^2+(Y2(i)-Y2(j))^2);
    end
end
cnt1(iter)=0;

for i=1:SearchAgents_no

    for j=1:SearchAgents_no

        if(All_dist2(i,j,iter)>R1 )

            cnt_isolated1(i,iter)=cnt_isolated1(i,iter)+1;

        end

    end

end

end

for i=1:SearchAgents_no

    N_no(iter,i)=SearchAgents_no-cnt_isolated1(i,iter)-1;

    if(cnt_isolated1(i,iter)==SearchAgents_no-1)

        cnt1(iter)=cnt1(iter)+1;

        N_isolated(iter,cnt1(iter))=i;

    end

end

end

for i=1:SearchAgents_no

    dist_BS(i)=sqrt((BS_X1-X2(i))^2+(BS_Y1-Y2(i))^2);

end

r1=(ub1-lb1)/4+((ub1-lb1)*(iter/Max_iteration)*2);

w1=rand;

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my_c1=rand;

if my_c1<0
    my_c1=1;
end

s1=rand;
a1=rand;
c1=rand;
f1=rand;
e1=rand;

for i=1:SearchAgents_no
    if(i~=SearchAgents_no)
        Fitness1(1,i)=(N_no(iter,i))+E_fly(iter,i)/(BS_X1-
X2(i))^2;

        Fitness1(2,i)=(N_no(iter,i))+E_fly(iter,i)/(BS_Y1-
Y2(i))^2;

        F_Fitness(iter,i)=sqrt(Fitness1(1,i)^2+Fitness1(2,i)^2);
    end

    if Fitness1(1,i)<Food_fitnessX1
        Food_fitnessX1=Fitness1(1,i);
        Food_posX1=X2(:,i);
    end

    if Fitness1(2,i)<Food_fitnessY1
        Food_fitnessY1=Fitness1(2,i);
        Food_posY1=Y2(:,i);
    end

    if Fitness1(1,i)>Enemy_fitnessX1
        if (all(X2(:,i)<ub1') && all(X2(:,i)>lb1'))
            Enemy_fitnessX1=Fitness1(1,i);
            Enemy_posX1=X2(:,i);
        end
    end
end

```

```

        end

    end

    if Fitness1(2,i)>Enemy_fitnessY1
        if (all(Y2(:,i)<ub1') && all(Y2(:,i)>lb1'))
            Enemy_fitnessY1=Fitness1(2,i);
            Enemy_posY1=Y2(:,i);
        end
    end

end

end

for i=1:SearchAgents_no
    for j=1:SearchAgents_no
        All_dist(i,j,iter)=sqrt((X2(i)-X2(j))^2+(Y2(i)-Y2(j))^2);
    end

    index1=0;
    neighbours_no=0;

    for j=1:SearchAgents_no
        Dist2Enemy1=sqrt((X2(i)-X2(j))^2+(Y2(i)-Y2(j))^2);

        if (all(Dist2Enemy1<R1) && all(Dist2Enemy1~=0))
            index1=index1+1;
            neighbours_no=neighbours_no+1;

            Neighbours_DeltaX1(:,index1)=DeltaX1(:,j);

            Neighbours_X1(:,index1)=X2(:,j);

            Neighbours_DeltaY1(:,index1)=DeltaY1(:,j);

            Neighbours_Y1(:,index1)=Y2(:,j);
        end
    end

end

Nbn(iter,i)=neighbours_no;
S_X1=0;

```

```

S_Y1=0;

if(N_no(iter,i)>1)
    for k=1:N_no(iter,i)
        N_dist(i,k,iter)=sqrt((Neighbours_X1(k)-
X2(i))^2+(Neighbours_Y1(k)-Y2(i))^2);
        S_X1=S_X1+(Neighbours_X1(k)-X2(i));
        S_Y1=S_Y1+(Neighbours_Y1(k)-Y2(i));
    end

    S_X1=-S_X1;
    S_Y1=-S_Y1;

else

    S_X1=0;
    S_Y1=0;

end

A_X1=0;
A_Y1=0;

if N_no(iter,i)>1
    for k=1:N_no(iter,i)
        A_X1=(sum(Neighbours_DeltaX1'))/N_no(iter,i);
        A_Y1=(sum(Neighbours_DeltaY1'))/N_no(iter,i);
    end

else

    A_X1=0;
    A_Y1=0;

end

C_tempX1=0;
C_tempY1=0;

if N_no(iter,i)>1
    for k=1:N_no(iter,i)

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```

        C_tempX1=(sum(Neighbours_X1'))/N_no(iter,i);
        C_tempY1=(sum(Neighbours_Y1'))/N_no(iter,i);

    end

else

    C_tempX1=0;
    C_tempY1=0;

end

C_X1=C_tempX1;
C_Y1=C_tempY1;

Dist2Food=sqrt((X2(i)-Food_posX1(:,1))^2+(Y2(i)-
Food_posY1(:,1))^2);

    if all(Dist2Food<=R1)

        F=sqrt((Food_posX1(:,1)-X2(:,i))^2+(Food_posY1(:,1)-
Y2(:,i))^2);
    else
        F=0;
    end

    Dist2Enemy1=sqrt((X2(:,i)-Enemy_posX1(:,1))^2+(Y2(:,i)-
Enemy_posY1(:,1))^2);

    if all(Dist2Enemy1<=R1)

        Enemy_X1=Enemy_posX1+X2(:,i);
        Enemy_Y1=Enemy_posY1+Y2(:,i);
    else

        Enemy_X1=0;
        Enemy_Y1=0;
    end

    if X2(i)>ub1
        X2(i)=lb1;
        DeltaX1(i)=rand;

    end

    if X2(i)<lb1
        X2(i)=ub1;
        DeltaX1(i)=rand;

    end
end

```

```

if Y2(i)>ub1
    Y2(i)=lb1;
    DeltaY1(i)=rand;

end

if Y2(i)<lb1
    Y2(i)=ub1;
    DeltaY1(i)=rand;

end

if any(Dist2Food>R1)

    if N_no(iter,i)>1

DeltaX1(i)=w1*DeltaX1(i)+rand*A_X1+rand*C_X1+rand*S_X1;

        if DeltaX1(i)>Delta_Xmax1
            DeltaX1(i)=Delta_Xmax1;

        end

        if DeltaX1(i)<=-Delta_Xmax1
            DeltaX1(i)=-Delta_Xmax1;

        end

        X2(i)=X2(i)+DeltaX1(i)/N_no(iter,i);

DeltaY1(i)=w1*DeltaY1(i)+rand*A_Y1+rand*C_Y1+rand*S_Y1;

        if DeltaY1(i)>Delta_Ymax1
            DeltaY1(i)=Delta_Ymax1;

        end

        if DeltaY1(i)<=-Delta_Ymax1
            DeltaY1(i)=-Delta_Ymax1;

        end

        Y2(i)=Y2(i)+DeltaY1(i)/N_no(iter,i);

    else

        dim1=1;
        X2(i)=X2(i)+Levy(dim1)'.*X2(i);
        DeltaX1(i)=0;
        Y2(i)=Y2(i)+Levy(dim1)'.*Y2(i);
        DeltaY1(i)=0;

    end

end

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```

else
    DeltaX1(i)=(a1*A_X1+c1*C_X1+s1*S_X1+f1*F+e1*Enemy_X1)+
w1*DeltaX1(i);

    if DeltaX1(i)>Delta_Xmax1
        DeltaX1(i)=Delta_Xmax1;
    end

    if DeltaX1(i)< -Delta_Xmax1
        DeltaX1(i)=-Delta_Xmax1;
    end

    X2(i)=X2(i)+DeltaX1(i);

    DeltaY1(i)=(a1*A_Y1+c1*C_Y1+s1*S_Y1+f1*F+e1*Enemy_Y1)+
w1*DeltaY1(i);

    if DeltaY1(i)>Delta_Ymax1
        DeltaY1(i)=Delta_Ymax1;
    end

    if DeltaY1(i)< -Delta_Ymax1
        DeltaY1(i)=-Delta_Ymax1;
    end

    Y2(i)=Y2(i)+DeltaY1(i);

end

end

clf(figure(3))

for i=1:SearchAgents_no;
figure(3)
hold on
plot(X2(i),Y2(i),'o')
text(X2(i),Y2(i),num2str(i))
plot(BS_X1,BS_Y1,'X')
xlabel('Distance (meter)','FontSize',10);
ylabel('Altitude (meter)','FontSize',10);
end
title('Final Network without DA')

```

```

WAIT=0.5;
pause(WAIT/5);
end

%save('DA_org_ed.mat')

figure(4)
plot(cnt,'b->','markersize',3,'Linewidth',2)
title('Isolated nodes count after DA')
xlabel('Number of iterations','FontSize',10);
ylabel('Number of isolated nodes','FontSize',10);
legend('DA')
grid on;

figure(5)
plot(cnt1,'m-*','markersize',3,'Linewidth',2)
title('Isolated nodes count without DA')
xlabel('Number of iterations','FontSize',10);
ylabel('Number of isolated nodes','FontSize',10);
legend('Without DA')
grid on;

figure(6)
hold on;
plot(cnt,'b->','markersize',3,'Linewidth',2)
hold on;
plot(cnt1,'m-*','markersize',3,'Linewidth',2)
title('Isolated nodes count')
xlabel('Number of iterations','FontSize',10);
ylabel('Number of isolated nodes','FontSize',10);
legend('DA','Without DA')
grid on;

```

```

function [ox,oy]=Levy2(d)
beta=3/2;
%Eq. (10)

```



```
sigma=(gamma(1+beta)*sin(pi*beta/2)/(gamma((1+beta)/2)*beta*2^((beta-1)/2)))^(1/beta);
uX=randn(1,d)*sigma;
vX=randn(1,d);
stepX=uX./abs(vX).^(1/beta);

uY=randn(1,d)*sigma;
vY=randn(1,d);
stepY=uY./abs(vY).^(1/beta);

% Eq. (9)
ox=0.01*stepX;
oy=0.01*stepY;
```

```
clear all
clc
close all
clf
```

```
SearchAgents_no=10; % Number of flying nodes
D=100;
```

```
x=D*rand(1,SearchAgents_no);
y=D*rand(1,SearchAgents_no);
z=D*rand(1,SearchAgents_no);
```

```
x1=D*rand(1,SearchAgents_no);
y1=D*rand(1,SearchAgents_no);
z1=D*rand(1,SearchAgents_no);
```

```

BS_X=50;
BS_Y=50;

BS_X1=50;
BS_Y1=50;

i=1:SearchAgents_no;
figure(1)
hold on
plot(x,y,'o')
plot(BS_X,BS_Y,'x')
xlabel('Distance (meter)','FontSize',10);
ylabel('Altitude (meter)','FontSize',10);
title('Initial Network Deployment')

for i=1:SearchAgents_no;
text(x(i),y(i),num2str(i))
end

Max_iteration=25; % Maximum numbef of iterations

lb=0;
ub=D;
dim=1;

lb1=0;
ub1=D;
dim1=1;

[X,Y,X1,Y1,E_fly,E_fly1]=DA_final(SearchAgents_no,Max_iteration,lb,ub,
dim,x,y,lb1,ub1,dim1,x1,y1);

```