RS-HL-4: Data Transmission by MDP algorithm

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Scope

Create Data Transmission Dataset from given contact matrix

I. Load the Data

```
clc; clear;
addpath('/workspace/RS_Dataset/')
load("RS_HL_3_Network_Graph_Generation.mat")

sat_to_sat_contact_3d_matrix(:,:,1);
gs_to_sat_contact_3d_matrix(:,:,1);
```

II. Specify the start GS and end GS and get the contact schedule

```
start_gs = 13;

end_gs = 28;


start_gs_contact_schedule = zeros(48,5761);
end_gs_contact_schedule = zeros(48,5761);

for i = 1:48
start_gs_contact_schedule(i,:) = gs_to_sat_contact_3d_matrix(start_gs,i,:);
end_gs_contact_schedule(i,:) = gs_to_sat_contact_3d_matrix(end_gs,i,:);
end

start_gs_contact_schedule;
end_gs_contact_schedule;
```

III. Contact Availability For GS

```
[row1,col1] = find(start_gs_contact_schedule == 1);
```

```
[row2,col2] = find(end_gs_contact_schedule == 1);

start_info = [row1,col1]
```

```
start_info = 2779×2
          24        1288
          24        1289
          24        1290
          24        1291
          24        1292
          24        1293
          24        1294
          24        1295
          23        1302
          23        1303
      ⋮
```

```
end_info = [row2,col2]
```

```
end_info = 1778×2
    37     1
    37     2
    37     3
    36     4
    37     4
    36     5
    37     5
    36     6
    37     6
    36     7
     ⋮
```

```
end_info = end_info(end_info(:,2) > start_info(1,2),:);

start_sat = start_info(1,1)
```

```
start_sat = 24
```

```

end_sat = end_info(1,1)
```

```
end_sat = 11
```

```

start_time = start_info(1,2)
```

```
start_time = 1288
```

```

end_time = end_info(1,2)
```

```
end_time = 2496
```

IV. MDP formulation

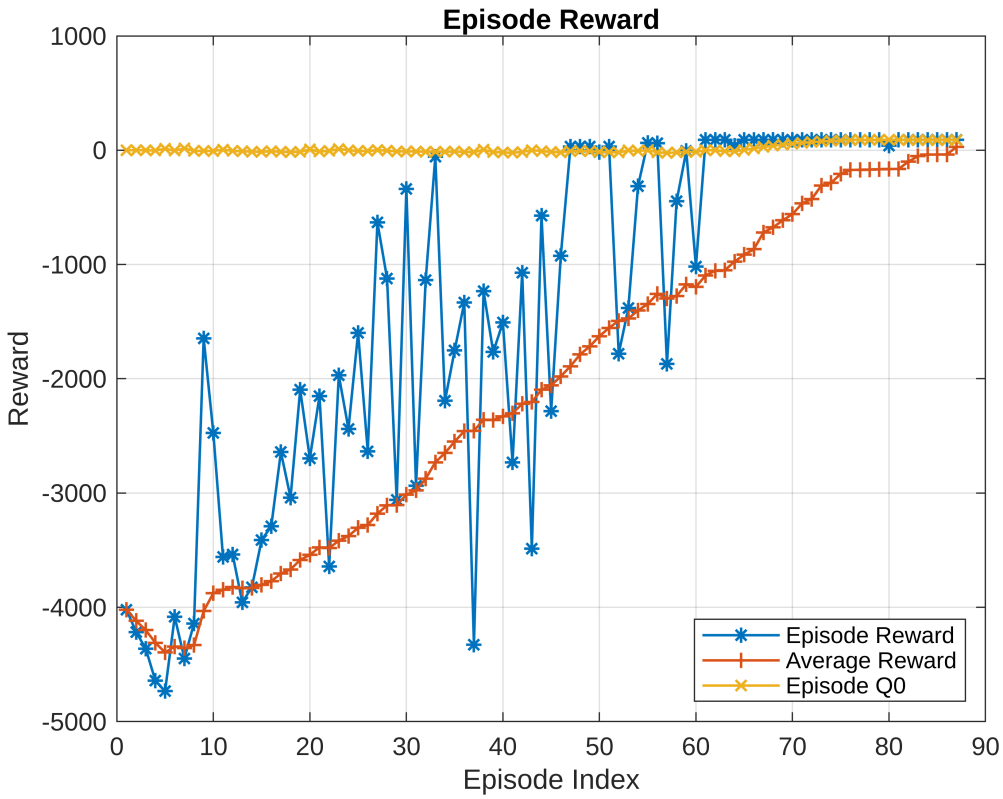
```
A = 1:48;
B = string(A');

MDP = createMDP(48,B);

time_stamp  = start_time;

gs_to_sat_matrix = gs_to_sat_contact_3d_matrix(:,:,time_stamp);
sat_to_sat_matrix = sat_to_sat_contact_3d_matrix(:,:,time_stamp);

MDP.TerminalStates = "s" + end_sat;

for i = 1:48
    for j = 1:48
        if sat_to_sat_matrix(i,j) == 1
        MDP.T(i,j,j) = sat_to_sat_matrix(i,j);


        if i < 25
            if j < 25
                MDP.R(i,j,j) = -1;
            end
            if j > 24
                MDP.R(i,j,j) = -15;
            end
        end

        if i > 24
            if j > 24
                MDP.R(i,j,j) = -1;
            end
            if j < 25
                MDP.R(i,j,j) = -15;
            end
        end

        if j == end_sat
            if j < 25
                if i > 24
                 MDP.R(i,end_sat,end_sat) = 50;
                end
                else
                MDP.R(i,end_sat,end_sat) = 100;
            end

            if j > 24
```

```
                if i < 25
                MDP.R(i,end_sat,end_sat) = 50;
                end
                else
                MDP.R(i,end_sat,end_sat) = 100;
            end
        end

        end

        if sat_to_sat_matrix(i,j) == 0
        MDP.T(i,i,j) = 1;
        MDP.R(i,i,j) = -50;
        end
    end
end
```

V. MDP Execution

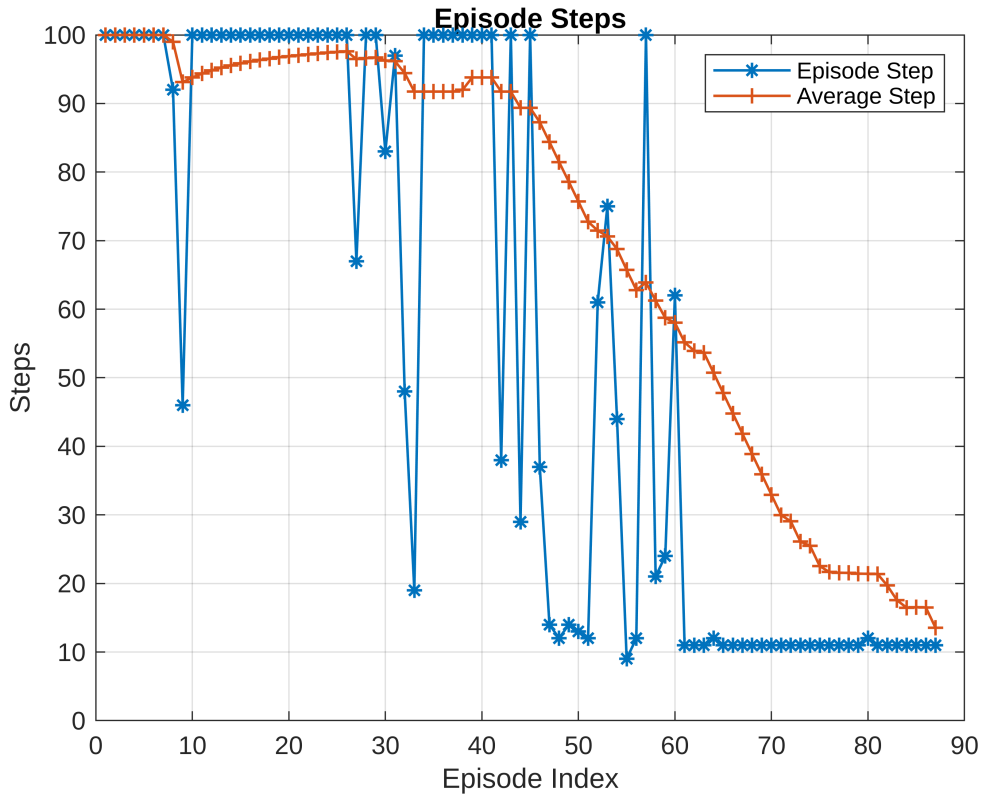
```
env = rlMDPEnv(MDP);

env.ResetFcn = @() start_sat;

rng(0)

obsInfo = getObservationInfo(env);
actInfo = getActionInfo(env);
qTable = rlTable(obsInfo, actInfo);
qFunction = rlQValueFunction(qTable, obsInfo, actInfo);
qOptions = rlOptimizerOptions(LearnRate=1);

agentOpts = rlQAgentOptions;
agentOpts.DiscountFactor = 1;
agentOpts.EpsilonGreedyExploration.Epsilon = 0.9;
agentOpts.EpsilonGreedyExploration.EpsilonDecay = 0.01;
agentOpts.CriticOptimizerOptions = qOptions;
qAgent = rlQAgent(qFunction,agentOpts); % #ok<NASGU>

trainOpts = rlTrainingOptions;
trainOpts.MaxStepsPerEpisode = 100;
trainOpts.MaxEpisodes = 500;
trainOpts.StopTrainingCriteria = "AverageReward";
trainOpts.StopTrainingValue = 13;
trainOpts.ScoreAveragingWindowLength = 30;

trainingStats = train(qAgent,env,trainOpts);

figure;
```

```
plot(trainingStats.EpisodeIndex,trainingStats.EpisodeReward,'LineWidth',1,'Ma
rker','*')
hold on
plot(trainingStats.EpisodeIndex,trainingStats.AverageReward,'LineWidth',1,'Ma
rker','+')
plot(trainingStats.EpisodeIndex,trainingStats.EpisodeQ0,'LineWidth',1,'Marker
','x')
hold off
title("Episode Reward")
xlabel("Episode Index")
ylabel("Reward")
legend('Episode Reward', 'Average Reward', 'Episode
Q0','Location','southeast')
grid on
```




```
figure;
plot(trainingStats.EpisodeIndex,trainingStats.EpisodeSteps,'LineWidth',1,'Mar
ker','*')
hold on
plot(trainingStats.EpisodeIndex,trainingStats.AverageSteps,'LineWidth',1,'Mar
ker','+')
hold off
title("Episode Steps")
xlabel("Episode Index")
ylabel("Steps")
```

```
legend('Episode Step', 'Average Step','Location','northeast')
grid on
```




```
```

VI. MDP Optimization Result

```
Data = sim(qAgent,env);

Satellites_list = reshape(Data.Observation.MDPObservations.Data, [],1)
```

```
Satellites_list = 12×1
    24
     1
     2
     3
     4
     5
     6
     7
     8
     9
     ⋮
```

```
No_of_SATS_passed = size(Data.Observation.MDPObservations.Data)
```

```
No_of_SATS_passed = 1×3
     1     1    12
```

```
Reward_list = Data.Reward.Data
```

```
Reward_list = 11×1
    -1
    -1
    -1
    -1
    -1
    -1
    -1
    -1
    -1
    -1
     ⋮
```

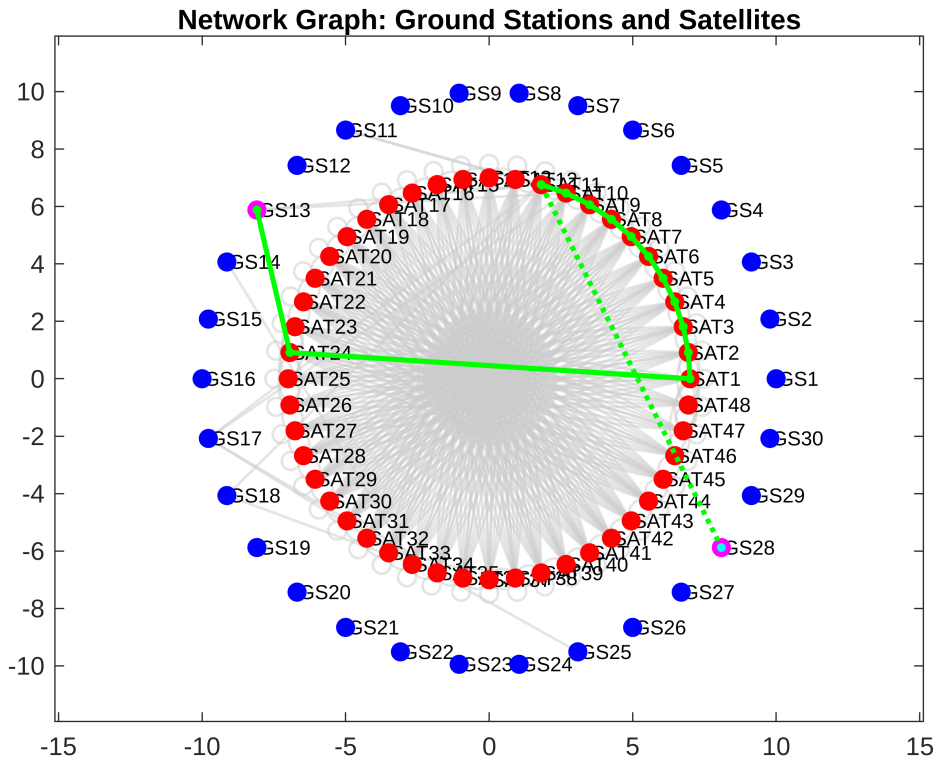
```
Total_reward = sum(Data.Reward.Data)
```

```
Total_reward = 90
```

VII. Graph Plot

```
GS_to_Sat = gs_to_sat_contact_3d_matrix(:,:,time_stamp);
Sat_to_Sat = sat_to_sat_contact_3d_matrix(:,:,time_stamp);

% Make Datasat Handovering SAT / GS

Data_Transmisson_Sequence = zeros(length(Satellites_list)+1,2);

Data_Transmisson_Sequence(1,:) = [ground_station_x(start_gs),
ground_station_y(start_gs)];


for ii = 1:length(Satellites_list)
Data_Transmisson_Sequence(ii+1,:) = [satellite_x(Satellites_list(ii)),
satellite_y(Satellites_list(ii))];
end

Data_Transmission_End = [satellite_x(end_sat),satellite_y(end_sat);
                         ground_station_x(end_gs), ground_station_y(end_gs)];


% Plot the network graph
figure;
plot(G, 'XData', x, 'YData', y, 'NodeColor', [0.6 0.6 0.6], 'EdgeColor',
[0.8 0.8 0.8], 'LineWidth', 1);
hold on;
```

```
% Plot the ground stations in blue and the satellites in red
plot(ground_station_x, ground_station_y, 'bo', 'MarkerSize', 7 ,
'MarkerFaceColor', 'b');
plot(satellite_x, satellite_y, 'ro', 'MarkerSize', 7, 'MarkerFaceColor',
'r');



% plot(satellite_x(start_sat), satellite_y(stVII. Graph Plotart_sat), 'ro',
'MarkerSize', 10, 'MarkerFaceColor', 'G');
% plot(satellite_x(end_sat), satellite_y(end_sat), 'ro', 'MarkerSize', 10,
'MarkerFaceColor', 'G');
% plot(ground_station_x(start_gs), ground_station_y(start_gs), 'bo',
'MarkerSize', 10 , 'MarkerFaceColor', 'G');
plot(ground_station_x(start_gs), ground_station_y(start_gs), 'mo',
'MarkerSize', 7 , 'MarkerFaceColor', 'M');
plot(ground_station_x(end_gs), ground_station_y(end_gs), 'mo', 'MarkerSize',
7 , 'MarkerFaceColor', 'M');
plot(Data_Transmisson_Sequence(:,1),Data_Transmisson_Sequence(:,2),'go',
'MarkerSize', 3, 'MarkerFaceColor', 'G')
plot(Data_Transmisson_Sequence(:,1),Data_Transmisson_Sequence(:,2),'g','LineW
idth',2);
plot(Data_Transmission_End(:,1),Data_Transmission_End(:,2),'LineStyle',':','C
olor','g','LineWidth',2);
plot(ground_station_x(end_gs), ground_station_y(end_gs), 'co', 'MarkerSize',
3 , 'MarkerFaceColor', 'c');

% Adjust the axis limits to fit the plot
axis equal;
title('Network Graph: Ground Stations and Satellites');
```


Network Graph: Ground Stations and Satellites
GS1
GS2
GS3
GS4
GS5
GS6
GS7
GS8
GS9
GS10
GS11
GS12
GS13
GS14
GS15
GS16
GS17
GS18
GS19
GS20
GS21
GS22
GS23
GS24
GS25
GS26
GS27
GS28
GS29
GS30
SAT1
SAT2
SAT3
SAT4
SAT5
SAT6
SAT7
SAT8
SAT9
SAT10
SAT17
SAT18
SAT19
SAT20
SAT21
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SAT24
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SAT26
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SAT28
SAT29
SAT30
SAT31
SAT32
SAT33
SAT40
SAT41
SAT42
SAT43
SAT44
SAT45
SAT46
SAT47
SAT48
10
8
6
4
2
0
-2
-4
-6
-8
-10
-15
-10
-5
0
5
10
15