```
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% ECE-559B
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% Question 1

clear;
clc;

global returns qvector searchrewards waitrewards startState
 actionsAtHigh actionsAtLow stepsize epsilon;

% To store average returns
% high - low
qvaluehighsearch = [0];
qvaluehighwait = [0];

qvaluelowsearch = [0];
qvaluelowwait = [0];
qvaluelowrecharge = [0];

Steps = 5000;

stepsize = 0.05;
epsilon = 0.1;

searchrewards = [3, 4, 5, 6];
waitrewards = [0, 1, 2];

pisearchhigh = 0.5;
piwaithigh = 0.5;
pisearchlow = 0.5;
piwaitlow = 0.25;
pirechargelow = 0.25;



loop = 1;
counterhigh = 0;
counterlow = 0;
% returns{0} high
% returns{1} low
returns = [0 0];

for outerloop = 1: Steps
    % selecting initial state as high = 1 or low = 2 with equal
 probability
    sequence = cell(1, 2);

    % Since SARSA is single step, generating a single step episode
    for k1 = 1:2
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        sequence{k1}.state = 0;
        sequence{k1}.action = 0;
        sequence{k1}.reward = 0;
    end

    % Selecting initial state randomly
    sequence{1}.state = randsample([1, 2], 1, true, [0.5, 0.5]);

    % Selecting initial action
    epsgreedy = rand;

    % Greedily
    if(epsgreedy <= (1 - epsilon))
        % If in state high
        if(sequence{1}.state == 1)
            % choosing greedily
            [maxValuedActions, I] = max([qvaluehighsearch(end),
qvaluehighwait(end)]);

            % Tie breaking between different same max valued actions
            sameValueActions = find([qvaluehighsearch(end),
qvaluehighwait(end)] == maxValuedActions);
            r = randi(length(sameValueActions));
            sequence{1}.action = sameValueActions(r);
        else
            % choosing greedily
            [maxValuedActions, I] = max([qvaluelowsearch(end),
qvaluelowwait(end), qvaluelowrecharge(end)]);

            % Tie breaking between different same max valued actions
            sameValueActions = find([qvaluelowsearch(end),
qvaluelowwait(end), qvaluelowrecharge(end)] == maxValuedActions);
            r = randi(length(sameValueActions));
            sequence{1}.action = sameValueActions(r);
        end
    else
        % Randomly with epsilon probability

        if(sequence{1}.state == 1)
            % if initial state is high, select search or wait randomly
            sequence{1}.action = randsample([1, 2], 1);
        else
            % if initial state is low, select search or wait or
recharge randomly
            sequence{1}.action = randsample([1, 2, 3], 1);
        end
    end


    % Determining reward and next state
    if(sequence{1}.state == 1)
        % action can be search = 1, wait = 2;
        if sequence{1}.action == 1
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          sequence{1+1}.state = randsample([1, 2],1, true, [0.25,
 0.75]);
          sequence{1}.reward =  randsample(searchrewards,1, true,
 [1/4, 1/4, 1/4, 1/4]);
        else
          sequence{1}.reward =  randsample(waitrewards,1, true, [1/3,
 1/3, 1/3]);
          sequence{1+1}.state = 1;
        end
    else
        % if in state low
        % action can be search = 1, wait = 2; recharge = 3;
        if sequence{1}.action == 1
          sequence{1+1}.state = randsample([2, 1], 1, true, [0.25,
 0.75]);
          if(sequence{1+1}.state == 2)
              sequence{1}.reward =  randsample(searchrewards,1, true,
 [1/4, 1/4, 1/4, 1/4]);
          else
              sequence{1}.reward = -3;
          end
        elseif(sequence{1}.action == 2)
          sequence{1}.reward =  randsample(waitrewards,1, true, [1/3,
 1/3, 1/3]);
          sequence{1+1}.state = 2;
        else
           sequence{1}.reward = 0;
           sequence{1+1}.state = 1;
        end
    end

% PLAIN SARSA - CHOOSING NEXT ACTION WITH EPISLON GREEDY
%     epsgreedy = rand;
%     if(epsgreedy < (1 - epsilon))
%         if(sequence{1+1}.state == 1)
%             % choosing greedily
%             [maxValuedActions, I] = max([qvaluehighsearch(end),
 qvaluehighwait(end)]);
%
%             % Tie breaking between different same max valued actions
%             sameValueActions = find([qvaluehighsearch(end),
 qvaluehighwait(end)] == maxValuedActions);
%         else
%             % choosing greedily
%             [maxValuedActions, I] = max([qvaluelowsearch(end),
 qvaluelowwait(end), qvaluelowrecharge(end)]);
%
%             % Tie breaking between different same max valued actions
%             sameValueActions = find([qvaluelowsearch(end),
 qvaluelowwait(end), qvaluelowrecharge(end)] == maxValuedActions);
%         end
%
%         r = randi(length(sameValueActions));
%
```

```
%         sequence{1+1}.action = sameValueActions(r);
%     else
%         if(sequence{1+1}.state == 1)
%             sequence{1+1}.action = randsample([1, 2], 1);
%         else
%             sequence{1+1}.action = randsample([1, 2, 3], 1);
%         end
%     end

    A = [qvaluehighsearch(end) qvaluehighwait(end)];
    maxval = max(A);
    lia = ismember(A,maxval);
    idx = find(lia);

    probability = 1;
    pihigh = {0, 0};
    for i = 1:numel(idx)
        pihigh{idx(i)} = (probability/numel(idx));
        if(size(idx) == 1)
            break;
        end
    end

    pisearchhigh = pihigh{1};
    piwaithigh = pihigh{2};

    A = [qvaluelowsearch(end) qvaluelowwait(end)
 qvaluelowrecharge(end)];
    maxval = max(A);
    lia = ismember(A,maxval);
    idx = find(lia);

    probability = 1;
    pilow = {0, 0, 0};
    for i = 1:numel(idx)
        pilow{idx(i)} = (probability/numel(idx));
        if(size(idx) == 1)
            break;
        end
    end

    pisearchlow = pilow{1};
    piwaitlow = pilow{2};
    pirechargelow = pilow{3};

% EXPECTED SARSA - CHOOSING NEXT ACTION WITH AN EXPECTATION
    if(sequence{1}.state == 1)
        % Choosing to search now
        if(sequence{1}.action == 1)
            if(sequence{2}.state == 1)
                % HIGH - SEARCH - HIGH
                temp = qvaluehighsearch(end) + stepsize *
 (sequence{1}.reward + 0.8 * (pisearchhigh * qvaluehighsearch(end) +
 piwaithigh * qvaluehighwait(end)) - qvaluehighsearch(end));
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            else
                % HIGH - SEARCH - LOW
                temp = qvaluehighsearch(end) + stepsize *
(sequence{1}.reward + 0.8 * (piwaitlow * qvaluelowwait(end)
+ pisearchlow * qvaluelowsearch(end) + pirechargelow *
qvaluelowrecharge(end)) - qvaluehighsearch(end));
            end
            qvaluehighsearch = [qvaluehighsearch; temp];
            qvaluehighwait = [qvaluehighwait; qvaluehighwait(end)];
        % Choosing to wait now
        elseif(sequence{1}.action == 2)
            % HIGH - WAIT - HIGH
            % next state is going to be high
             temp = qvaluehighwait(end) + stepsize *
(sequence{1}.reward + 0.8 * (pisearchhigh * qvaluehighsearch(end) +
piwaithigh * qvaluehighwait(end)) - qvaluehighwait(end));
             qvaluehighwait = [qvaluehighwait; temp];
             qvaluehighsearch = [qvaluehighsearch;
qvaluehighsearch(end)];
        end

        qvaluelowsearch = [qvaluelowsearch; qvaluelowsearch(end)];
        qvaluelowwait = [qvaluelowwait; qvaluelowwait(end)];
        qvaluelowrecharge = [qvaluelowrecharge;
qvaluelowrecharge(end)];
    else
        % At state low

        % Choosing to search
        if(sequence{1}.action == 1)
            if(sequence{2}.state == 1)
                % LOW - SEARCH - HIGH
                % next state high - so can only perform searc and wait
in next state.
                temp = qvaluelowsearch(end) + stepsize *
(sequence{1}.reward + 0.8 * (pisearchhigh * qvaluehighsearch(end) +
piwaithigh * qvaluehighwait(end)) - qvaluelowsearch(end));
            else
                 % LOW - SEARCH - LOW
                % next state low - so can perform search, wait and
recharge in next state.
                 temp = qvaluelowsearch(end) + stepsize *
(sequence{1}.reward + 0.8 * (piwaitlow * qvaluelowwait(end)
+ pisearchlow * qvaluelowsearch(end) + pirechargelow *
qvaluelowrecharge(end)) - qvaluelowsearch(end));
            end
            qvaluelowsearch = [qvaluelowsearch; temp];
            qvaluelowwait = [qvaluelowwait; qvaluelowwait(end)];
            qvaluelowrecharge = [qvaluelowrecharge;
qvaluelowrecharge(end)];

        % Choosing to wait
        elseif(sequence{1}.action == 2)
            % LOW - WAIT - LOW
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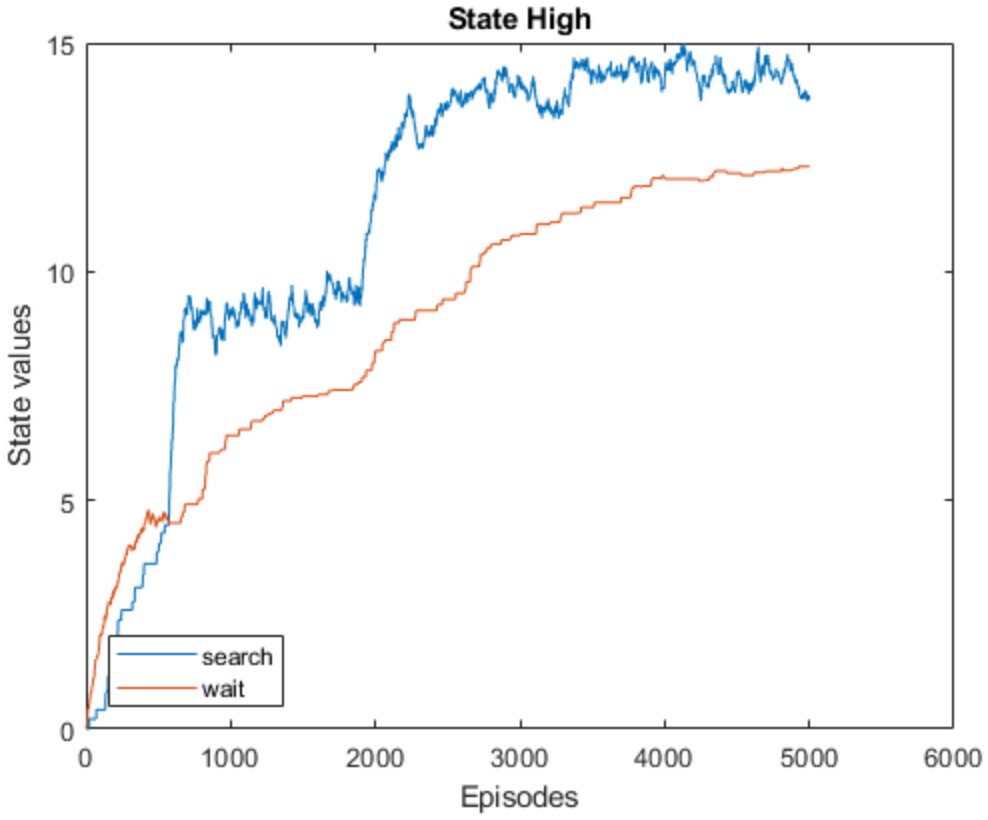
```
            temp = qvaluelowwait(end) + stepsize * (sequence{1}.reward
 + 0.8 * (piwaitlow * qvaluelowwait(end) + pisearchlow *
 qvaluelowsearch(end) + pirechargelow * qvaluelowrecharge(end)) -
 qvaluelowwait(end));
            qvaluelowwait = [qvaluelowwait; temp];
            qvaluelowsearch = [qvaluelowsearch; qvaluelowsearch(end)];
            qvaluelowrecharge = [qvaluelowrecharge;
 qvaluelowrecharge(end)];

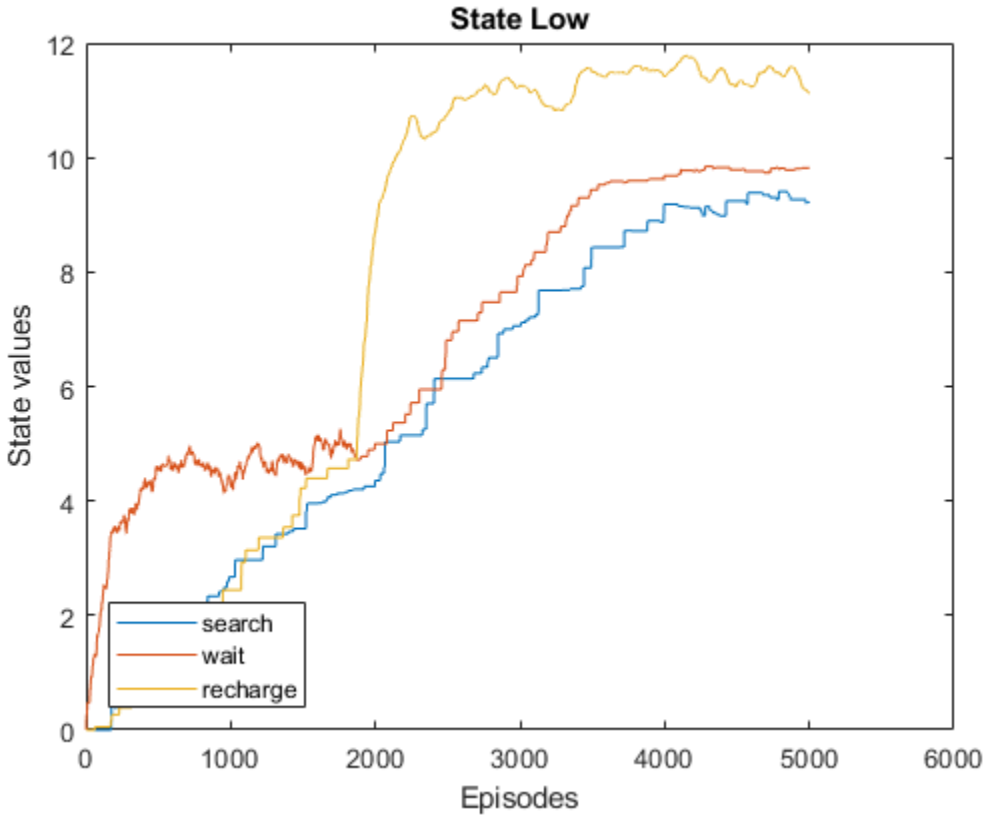
        % Choosing to recharge at low
        else
            % LOW - RECHARGE - HIGH
            temp = qvaluelowrecharge(end) + stepsize *
 (sequence{1}.reward + 0.8 * (pisearchhigh * qvaluehighsearch(end) +
 piwaithigh * qvaluehighwait(end)) - qvaluelowrecharge(end));
            qvaluelowrecharge = [qvaluelowrecharge; temp];
            qvaluelowsearch = [qvaluelowsearch; qvaluelowsearch(end)];
            qvaluelowwait = [qvaluelowwait; qvaluelowwait(end)];
        end
        qvaluehighsearch = [qvaluehighsearch; qvaluehighsearch(end)];
        qvaluehighwait = [qvaluehighwait; qvaluehighwait(end)];
    end
end
% celldisp(sequence);

t1=1:length(qvaluehighsearch);
t2=1:length(qvaluehighwait);
t3=1:length(qvaluelowsearch);
t4=1:length(qvaluelowwait);
t5=1:length(qvaluelowrecharge);

figure(1)
plot(t1, qvaluehighsearch, t2,qvaluehighwait);
xlabel('Episodes')
ylabel('State values')
legend({'search','wait'},'Location','southwest')
title('State High');

figure(2)
plot(1:length(qvaluelowsearch), qvaluelowsearch,
 1:length(qvaluelowwait), qvaluelowwait, 1:length(qvaluelowrecharge),
 qvaluelowrecharge);
xlabel('Episodes')
ylabel('State values')
legend({'search','wait', 'recharge'},'Location','southwest')
title('State Low');
```


State High
State values
Episodes
search
wait
0
5
10
15
0
1000
2000
3000
4000
5000
6000


State Low
State values
Episodes
search
wait
recharge
0
2
4
6
8
10
12
0
1000
2000
3000
4000
5000
6000

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