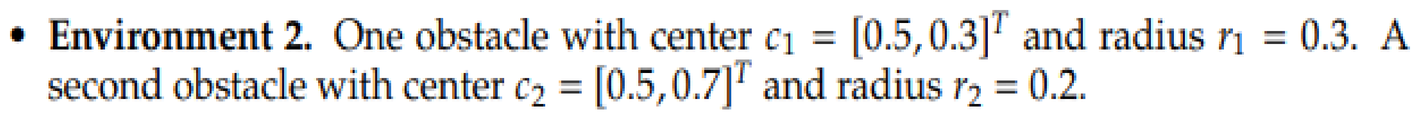
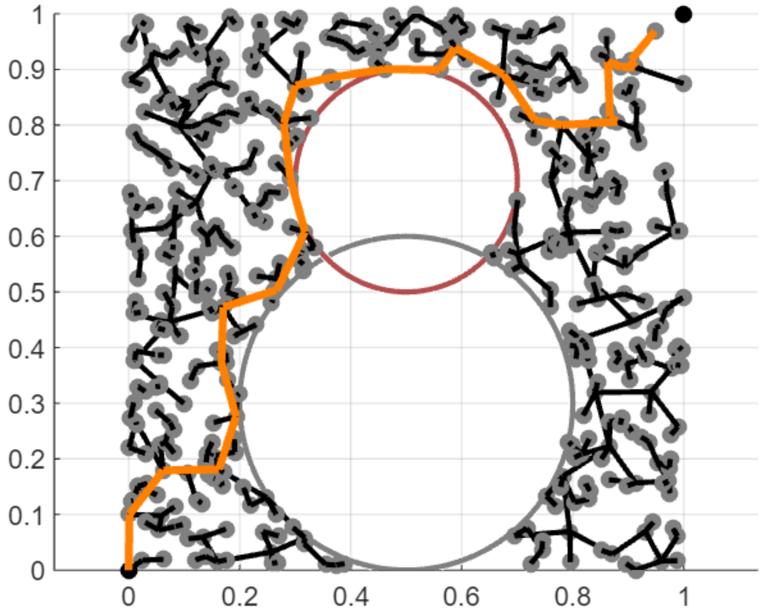


- **Environment 2.** One obstacle with center $c_1 = [0.5, 0.3]^T$ and radius $r_1 = 0.3$. A second obstacle with center $c_2 = [0.5, 0.7]^T$ and radius $r_2 = 0.2$.

```
clear
close all

% Define start and goal positions
theta_start.coord = [0; 0];
theta_goal = [1; 1];

% Define obstacles
center = [0.5; 0.3];
radius = 0.3;
center2 = [0.5; 0.7]; % Second obstacle center
radius2 = 0.2;        % Second obstacle radius

% Parameters
epsilon = 0.1;
delta = 0.1;
N = 1000;

% Visualize environment
figure
grid on
hold on
axis([0, 1, 0, 1])
axis equal
viscircles(center', radius, 'Color', [0.5, 0.5, 0.5]);
viscircles(center2', radius2, 'Color', [0.7, 0.3, 0.3]); % Visualizing the second
obstacle
plot(0, 0, 'ko', 'MarkerFaceColor', 'k')
plot(1, 1, 'ko', 'MarkerFaceColor', 'k')

% Initialize tree
theta_start.parent = 0;
G(1) = theta_start;

for idx = 1:N

    % Stop if the last node in G is close to theta_goal
    if norm(G(end).coord  - theta_goal) < epsilon
        break
    end

    % sample random joint position
    theta_rand = rand(2,1);
    % % theta_rand = theta_goal;
    % % if rand() < 0.8
    % %     theta_rand = rand(2,1);
    % % end

    % Find node in G nearest to theta_rand
    min_dist = inf;
    theta_near_index = 0;

    for jdx = 1:length(G)
        coord = G(jdx).coord;
        dist = norm(theta_rand - coord);
        if dist < min_dist
            min_dist = dist;
            theta_near_index = jdx;
        end
    end

    theta_near = G(theta_near_index);
    % Take a step from theta_near towards theta_rand
    vec_to_rand = theta_rand - theta_near.coord;
    dist_to_rand = norm(vec_to_rand);
    if dist_to_rand < delta
        theta_new.coord = theta_rand;
    else
        theta_new.coord = theta_near.coord + delta * ...
        vec_to_rand/dist_to_rand;
    end

    % Check if theta_new is collision free with both obstacles
    dist_to_obs1 = norm(theta_new.coord - center);
    dist_to_obs2 = norm(theta_new.coord - center2);
    if dist_to_obs1 < radius || dist_to_obs2 < radius2
        continue
    end

    % If collision free, add theta_new to tree with parent theta_near
    theta_new.parent = theta_near_index;
    G = [G, theta_new];

    % Plot node and edge
    plot(theta_new.coord(1), theta_new.coord(2), 'o', 'Color', [0.5, 0.5, 0.5], ...
    'MarkerFaceColor', [0.5, 0.5, 0.5])
    line([theta_near.coord(1), theta_new.coord(1)], [theta_near.coord(2), ...
    theta_new.coord(2)], 'Color', 'k', 'LineWidth', 2);
    drawnow

end

% Work backwards from the final node to the root of the tree
child_theta = G(end);
while child_theta.parent ~= 0
```

```
    parent_theta_index = child_theta.parent;
    parent_theta = G(parent_theta_index);
    line([child_theta.coord(1), parent_theta.coord(1)], ...
        [child_theta.coord(2), parent_theta.coord(2)], ...
        'Color', [1, 0.5, 0], 'LineWidth', 3);
    child_theta = parent_theta;
end
```


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1