ROBT403 HW3: Obstacle avoidance by a robot using ANN.

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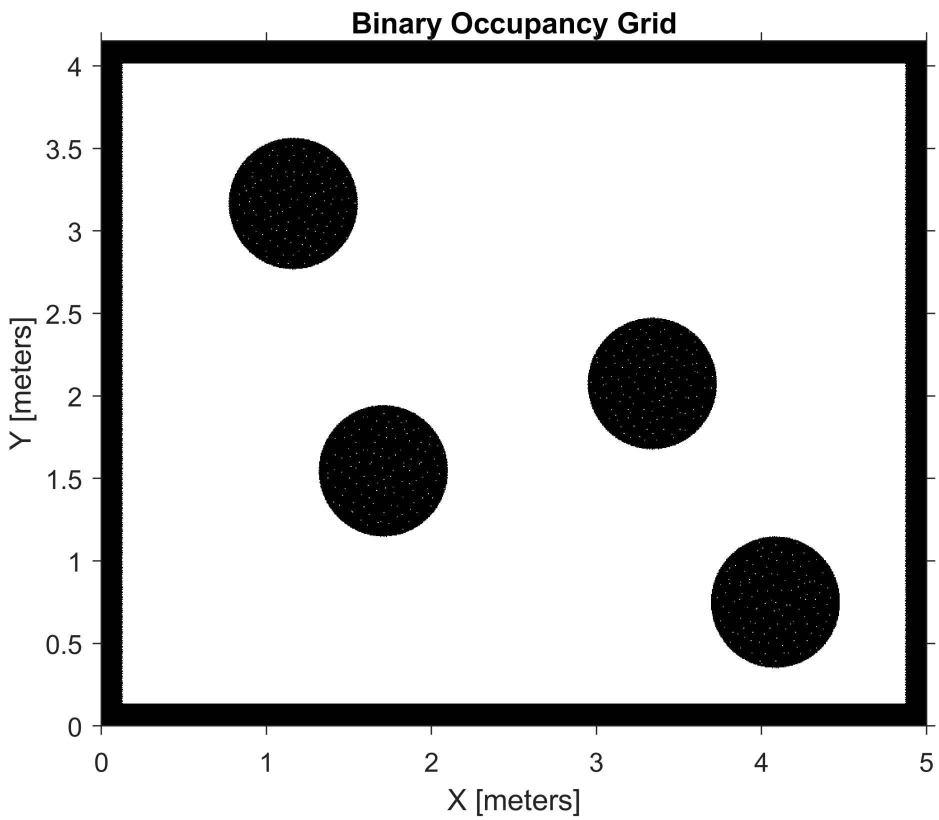
The map was created by photoshop editor in png format and only then converted into pbm. I order to make the environment suitdul the map implemented by using navigator toolbox. However, the whole project is mainly done by Mobile Robotics Simulation Toolbox.

Simulation setup

Define Vehicle

```
R = 0.1;                        % Wheel radius [m]
L = 0.3;                        % Wheelbase [m]
% dd = DifferentialDrive(R,L);
dd_robot = [R L];

% Sample time and time array
sampleTime = 0.01;              % Sample time [s]

% Initial conditions
initPose = [0.5; 0.5; -pi/2];            % Initial pose (x y theta)

% Load map
close all
testmap = imread('test1.pbm');
map = robotics.BinaryOccupancyGrid(testmap, 200);
show(map)
```



Create and Modify Binary Occupancy Grid

Here, I used Visualizer2D and LidarSensor to create a robot with the radius equal to 0.1, and to use sensors to avoid obstacles in the range of 0.5.

```
% Create lidar sensor
lidar = LidarSensor;
% 11 sensors were used
lidar.scanAngles = [-pi/2,-pi/3,-pi/4, -pi/6,-pi/9, 0,pi/9, pi/6,pi/4,pi/3,pi/2];
lidar.maxRange = 0.5;

% Create visualizer
viz = Visualizer2D;
viz.hasWaypoints = true;
viz.showTrajectory = true;
viz.robotRadius = 0.1;
viz.mapName = 'map';
attachLidarSensor(viz,lidar);
```

Path planning and following to the destination point

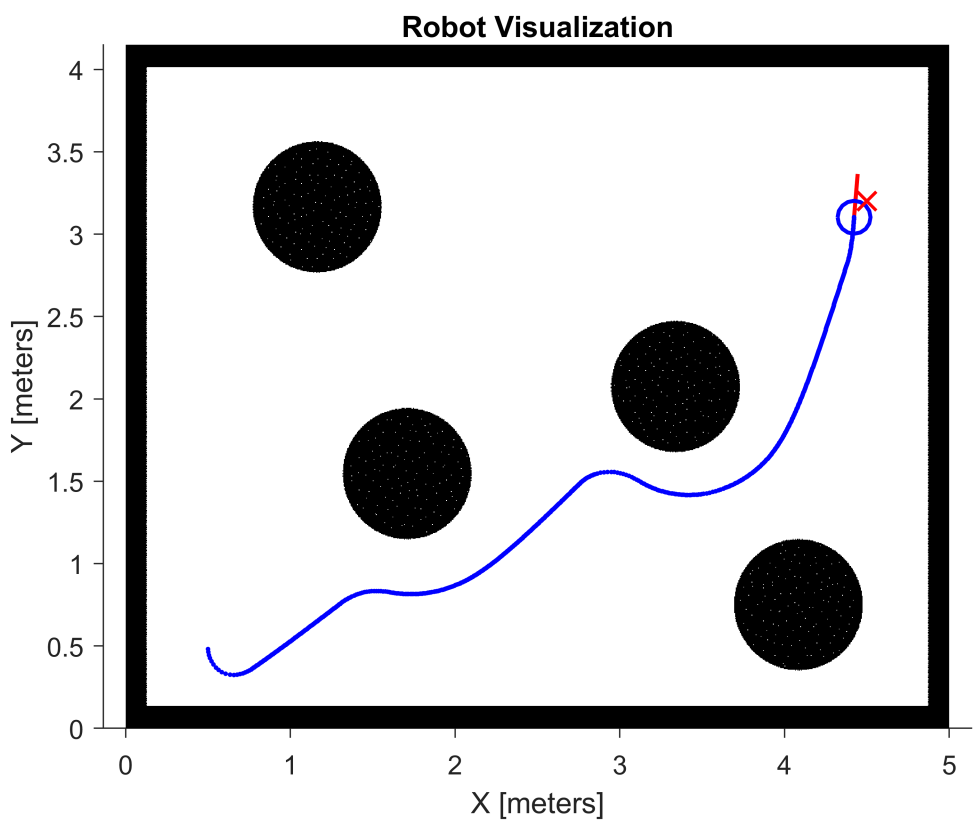
```
waypoints = [4.5 3.2];   % the destination point
```

Simulation loop

The moving to the destination loop works until the destination is reached. First, the direction is calculated in degrees (to understand easier). Then, the direction angle is normalized between -0.5 and 0.5 in order to be able to impact the wheels differently for steering to destination (so 0 is correct direction, no steering needed). Then, the sensor readings are collected to a matrix and normalized between 0.1 and 1 and the inverse is fed to the ANN. The inverse is used so that the closer obstacles will have more effect than the obstacles further. Bias of 0.2 was used in order to have the positive velocity consistently.

```
idx = 1;
pose = initPose;

while((abs(waypoints(1)-initPose(1))>.1)||(abs(initPose(2)-waypoints(2))>.1))
    next_pose = [0; 0; 0];
    % concatenate next pose to the pose matrix
    pose = [pose next_pose];
    % calculate the direction to target
    % (degrees to understand easier)
    targetDir = rad2deg(atan2(waypoints(2)-initPose(2),...
                waypoints(1)-initPose(1)) - initPose(3));

    % make the direction circulat in -180 - 180 degrees
    if targetDir > 180
        targetDir = targetDir - 360;
    elseif targetDir < -180
        targetDir =  360 + targetDir;
    end
    % the direction angle is normalized between -0.5 and 0.5
    % in order to be able to impact the wheels differently
    % for steering to destination
    % so 0 is correct direction, no steering needed.
    targetDir = ((targetDir+180)/(2*180)) - 0.5;

    % inputs from sensor
    ranges = (lidar(initPose) - viz.robotRadius); % inputs in range 0 - 0.25m

    % normalize for ANN
    rangesN = (ranges+0.1)/0.4;

    % create ANN
    % inputs matrix --> [dir, CC, CR, CL, CRR, CLL]
    inputs = [targetDir, 1/rangesN(3), 1/rangesN(2),...
              1/rangesN(4), 1/rangesN(1), 1/rangesN(5)];
    % the sensor readings are collected to a matrix
    % and normalized between 0.1 and 1 and the inverse
    % is fed to the ANN to change NaN inputs to 0
    inputs (isnan(inputs)) = 0;

    % ANN
    weights = [-0.9, -0.15, 0, 0.35, 0, 0.5;  % left wheel
                0.9, -0.15, 0.35, 0, 0.5, 0]; % right wheel
    bias = 0.2; % in order to have positive velocity
```

```
    activation = (weights * inputs.') + bias;
    leftWheel = activation(1)*30;
    rightWheel = activation(2)*30;

    % calc Forward Kinematics
    [v, y, w] = FK(dd_robot,leftWheel,rightWheel);

    % calculate the velocity of the robot relative to the map
    velocity = rtm([v; y; w], initPose);

    % calculate next pose
    pose(:,idx+1) = initPose + velocity * sampleTime;

    % move toward waypoint
    viz(pose(:,idx+1), waypoints, ranges)

    % iterate the counter and current pose variable
    idx = idx + 1;
    initPose = pose(:,idx);
end
```




```
function [v, y, w] = FK(robot, LW, RW)
    y = 0; % zero lateral velocity (for rtm)
    v = 0.5 * robot(1) * (LW + RW);
```

```
    w = (RW - LW) * robot(1)/robot(2);
end

function velocity = rtm(V, pose)
    angle = pose(3);
    velocity = [cos(angle) -sin(angle) 0; sin(angle) cos(angle)  0; 0 0 1]*V;
end
```