ROBT403 HW3: Obstacle avoidance by a robot using ANN.

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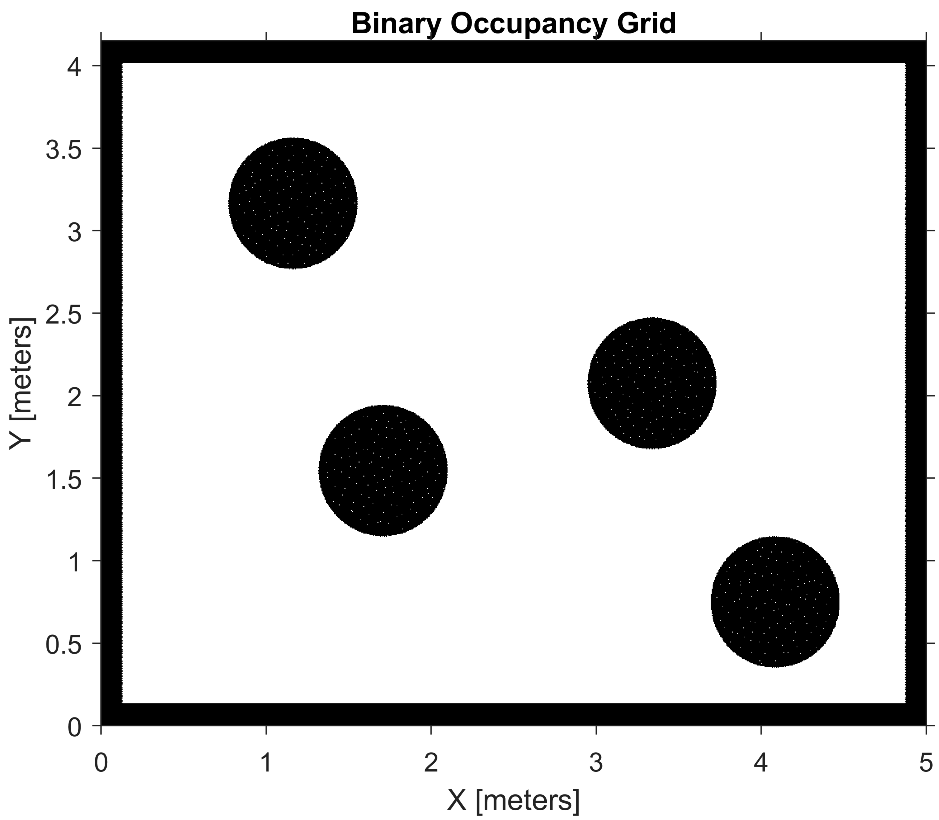
The map was created by photoshop editor in png format and only then converted into pbm. I order to make the environment suitdul the map implemented by using navigator toolbox. However, the whole project is mainly done by Mobile Robotics Simulation Toolbox.

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);
```

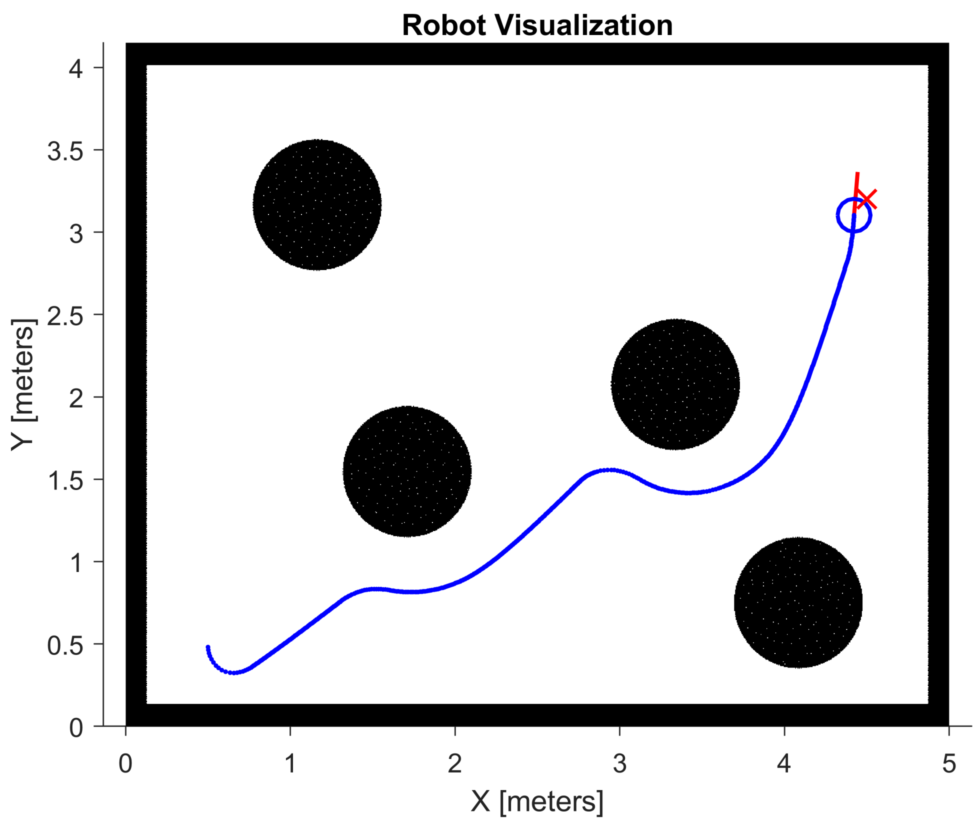
Path planning and following to the destination point

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

Simulation loop

```
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
```