定位与建图

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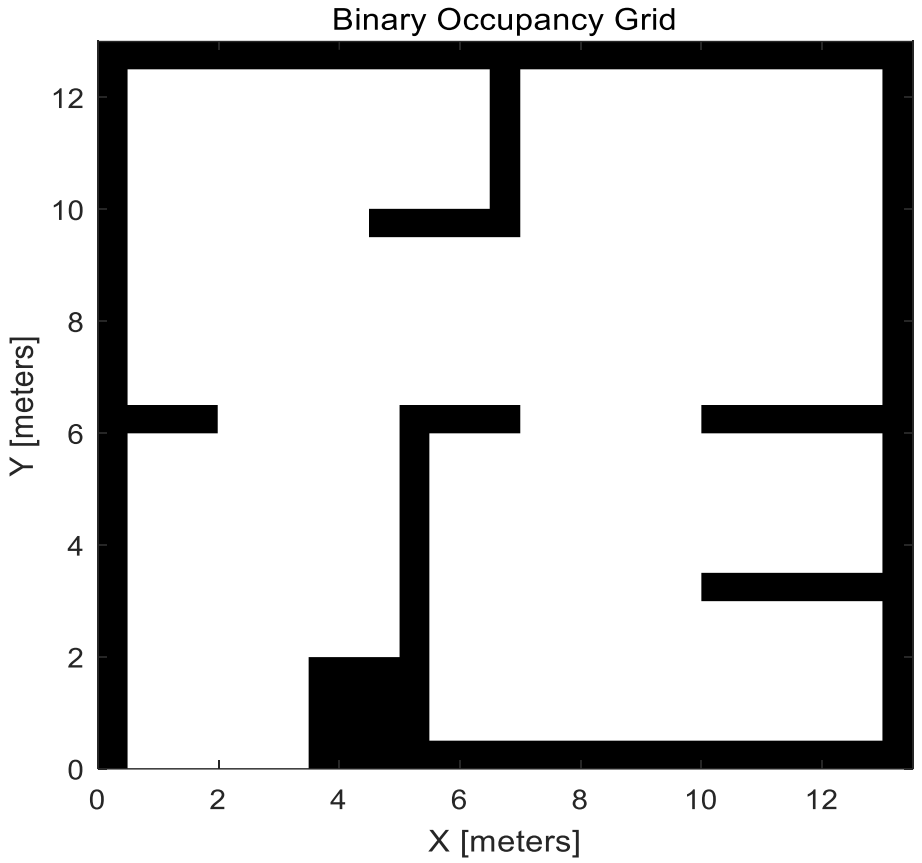
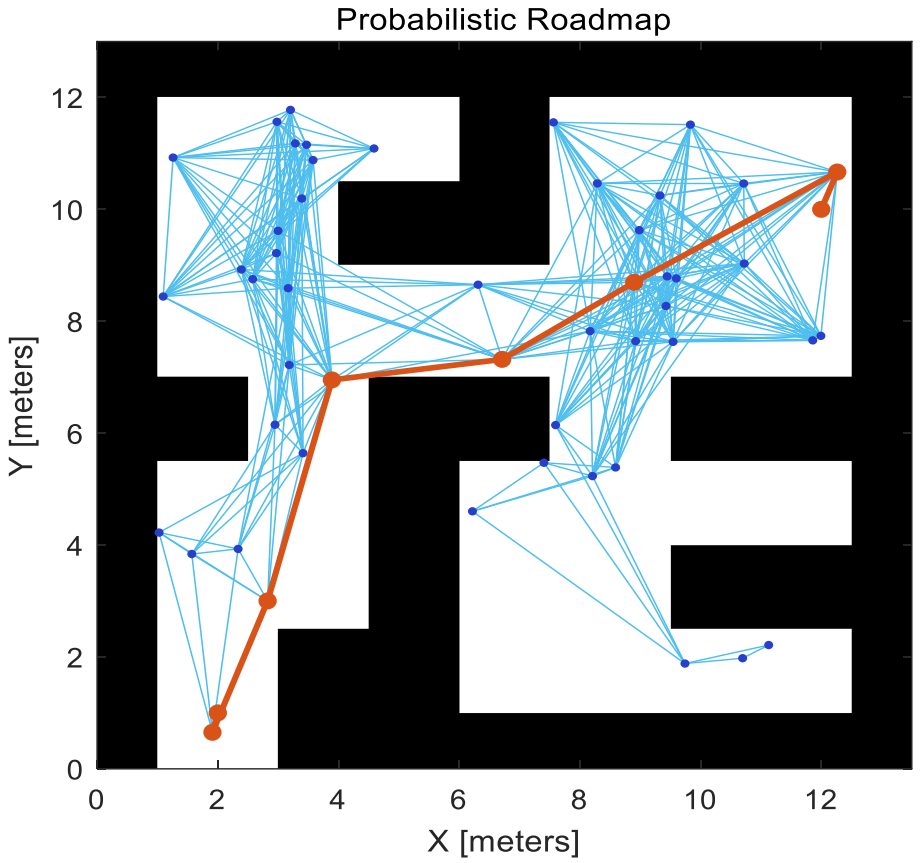
智能汽车研究所

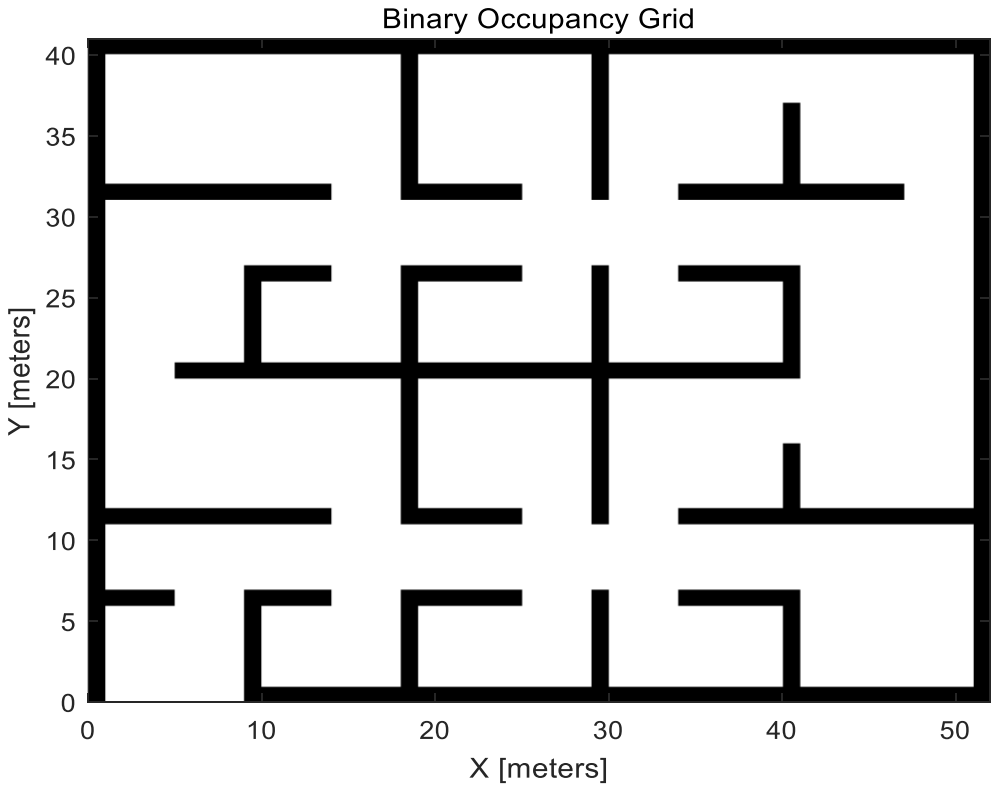
Demo: 不同复杂性环境中的路径规划

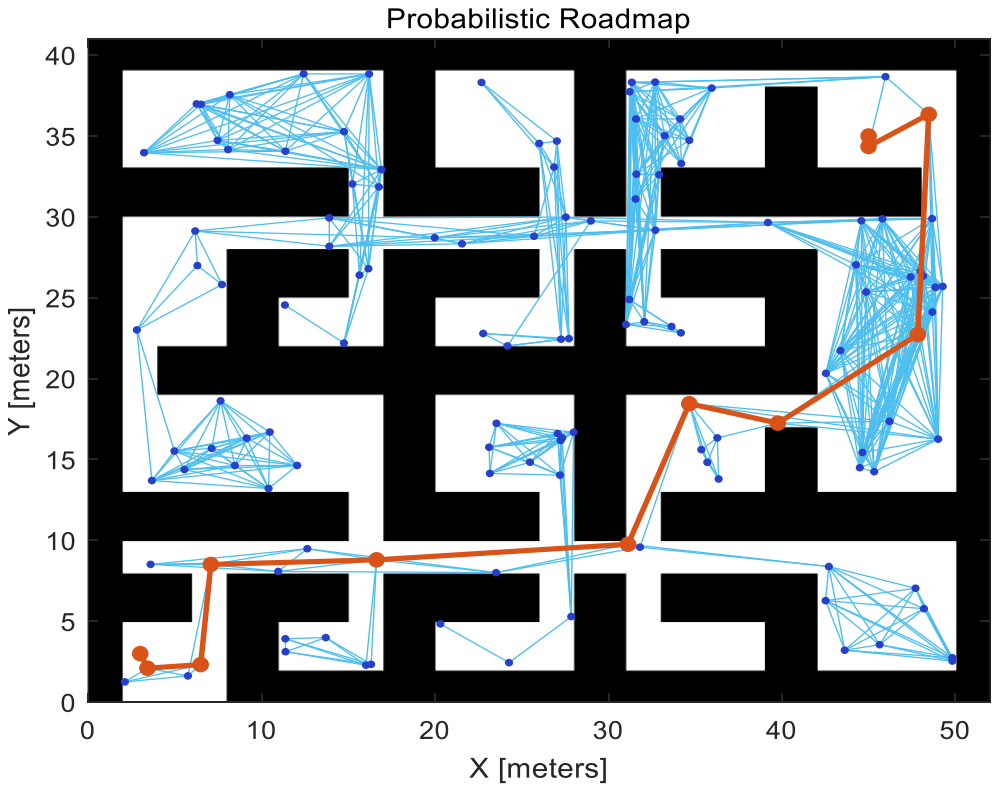
Path Planning in Environments of Different Complexity





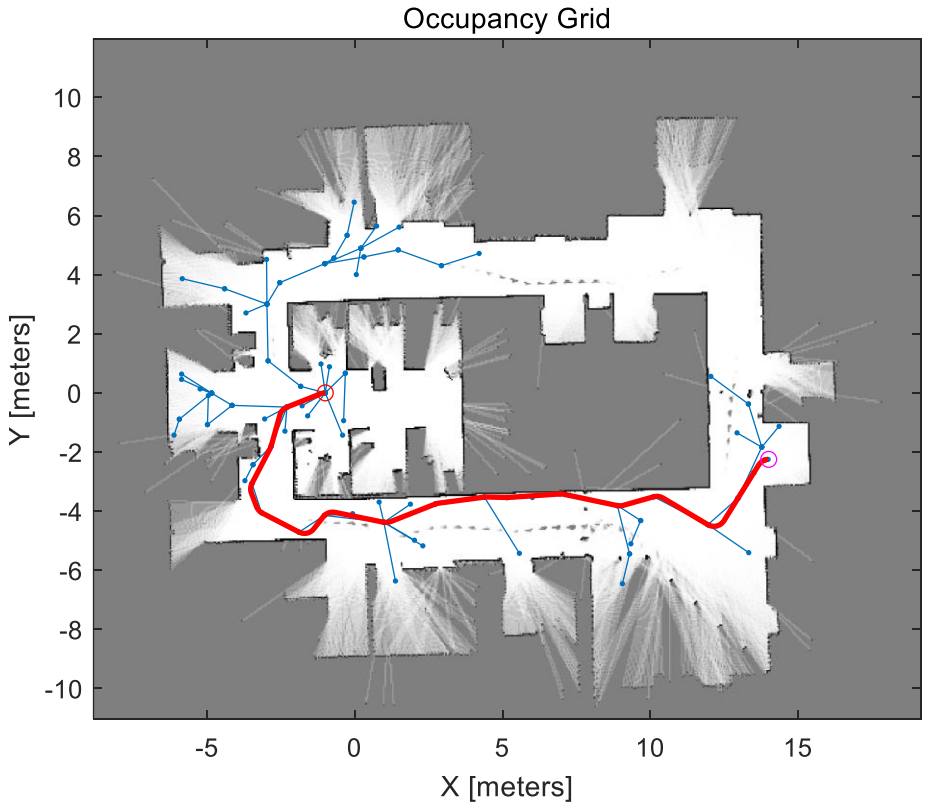
Demo: 不同复杂性环境中的路径规划

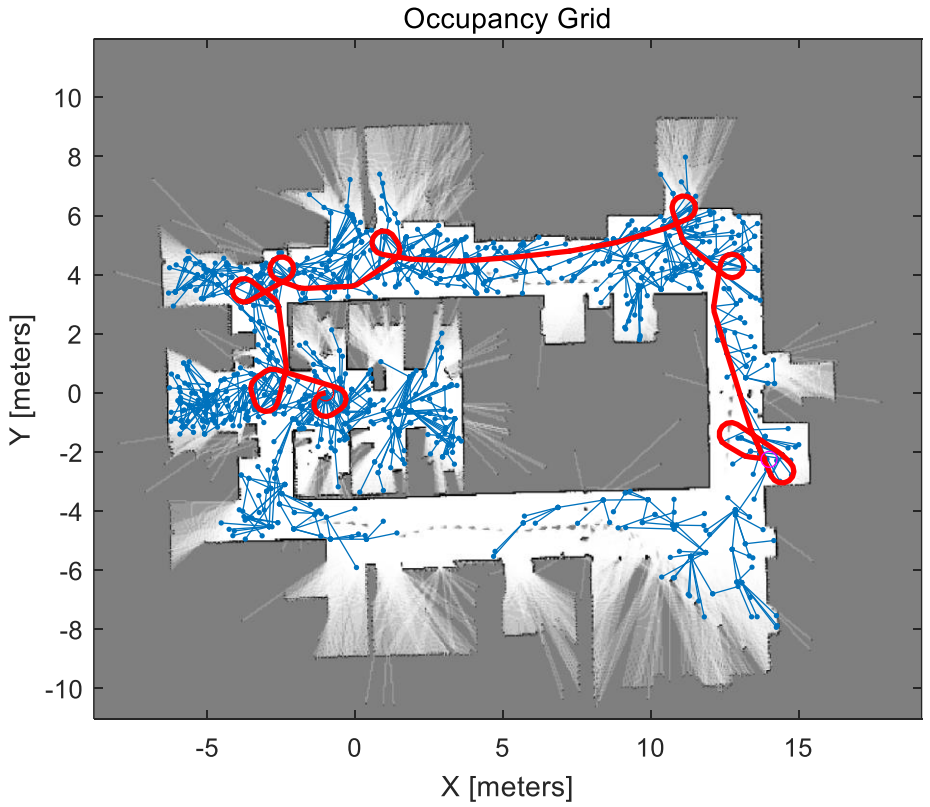




Demo: 使用RRT规划移动机器人路径

Plan Mobile-Robot Paths using RRT

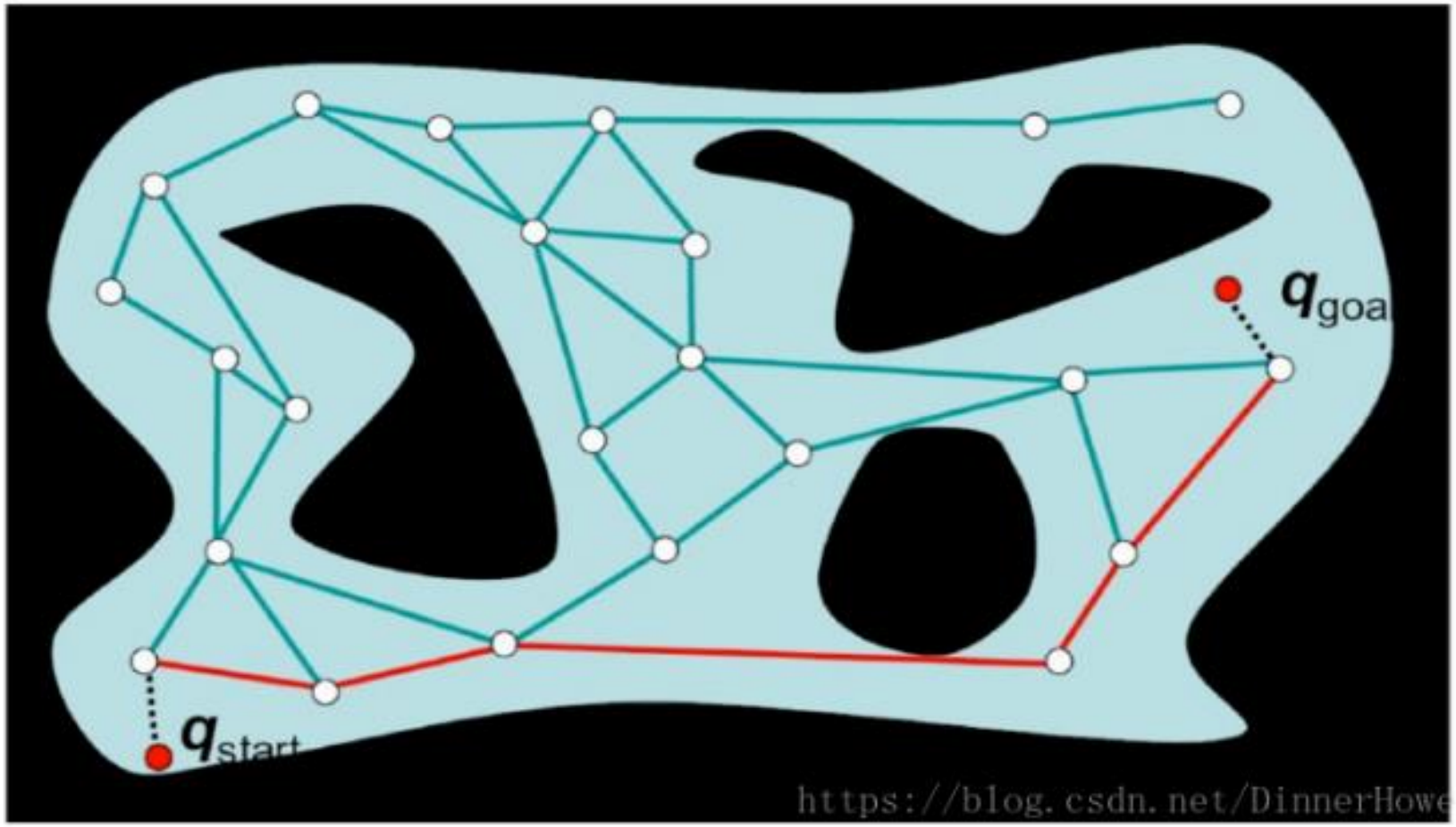




PRM-概率路线图

Probabilistic Roadmaps (PRM)

将起点和终点与PRM相连，并用A*来搜索

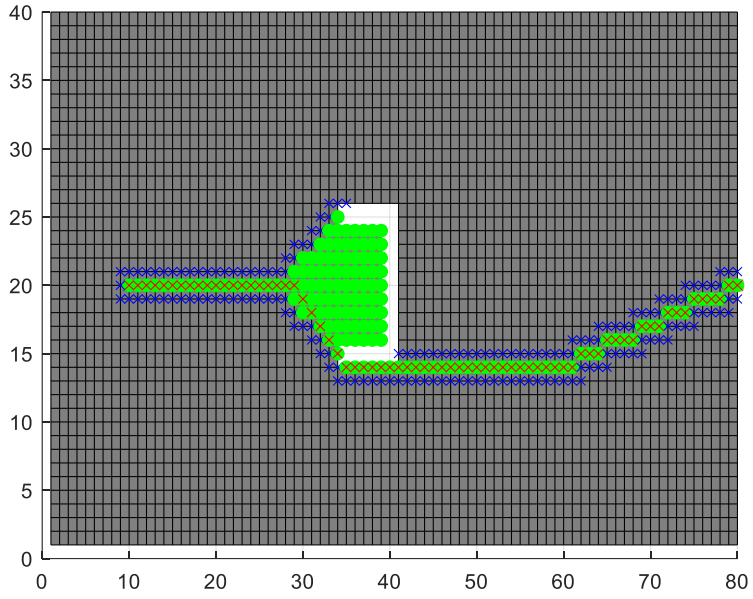


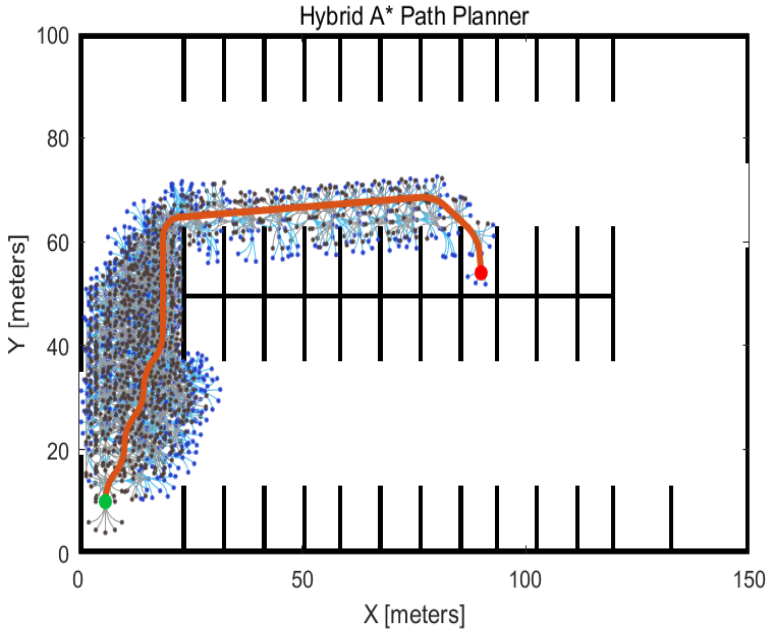
A star

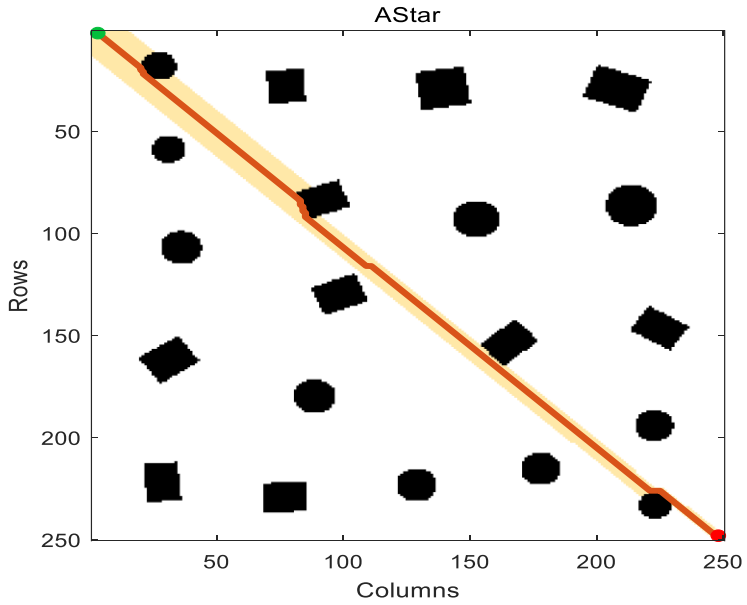
https://www.mathworks.com/matlabcentral/fileexchange/64978-a-star-search-algorithm

plannerHybridAStar

plannerAStarGrid

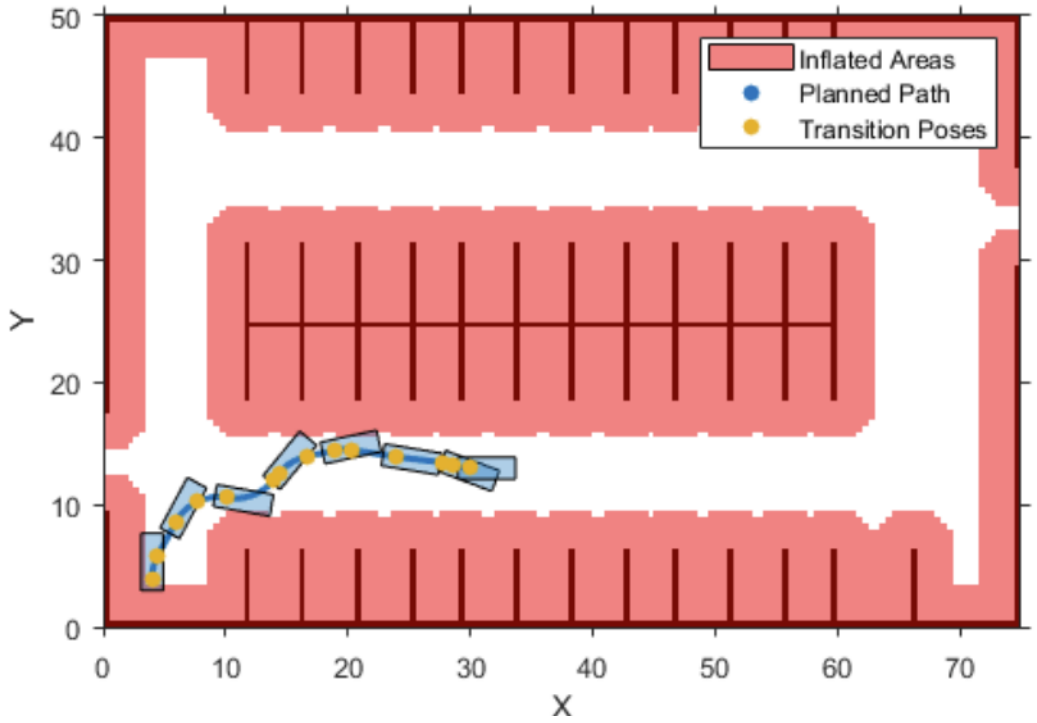




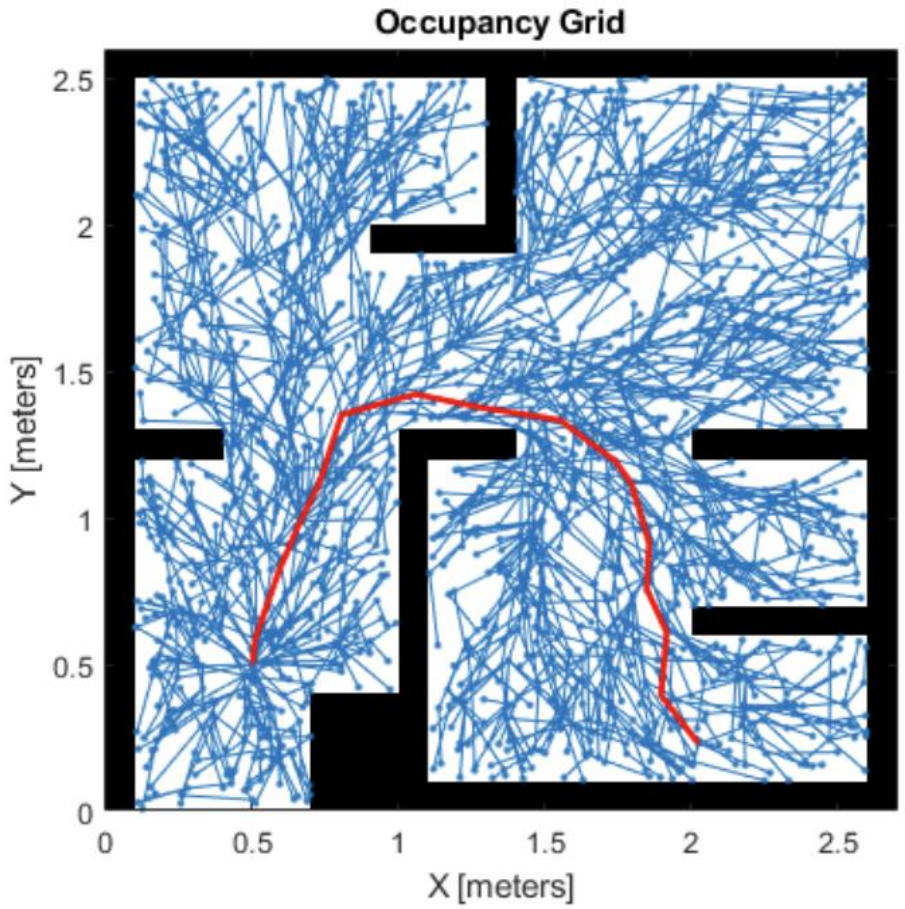


RRT RRTStar

pathPlannerRRT



plannerRRTStar

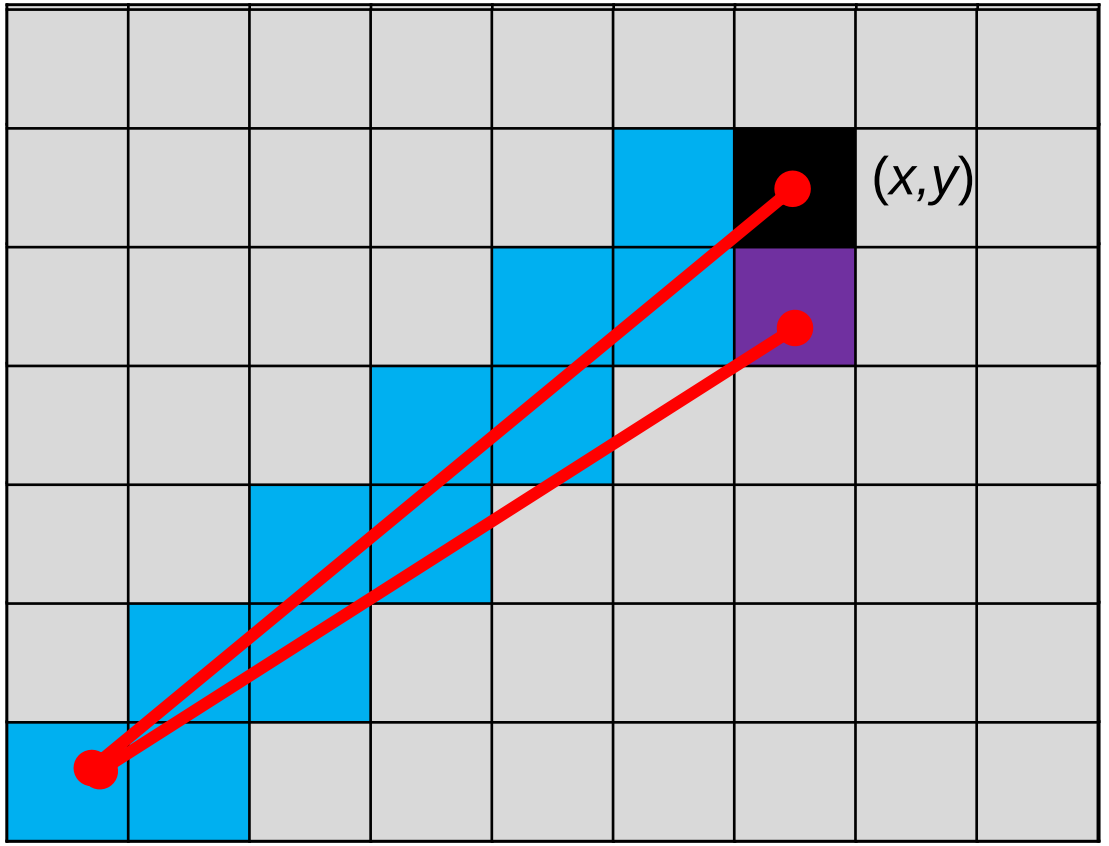


Occupancy Grids

$$l_t = l_{t-1} + \log \frac{p(x|z_t)}{1 - p(x|z_t)} - \log \frac{p(x)}{1 - p(x)}$$

$$l(x) = \log\left(\frac{p(x)}{1 - p(x)}\right)$$

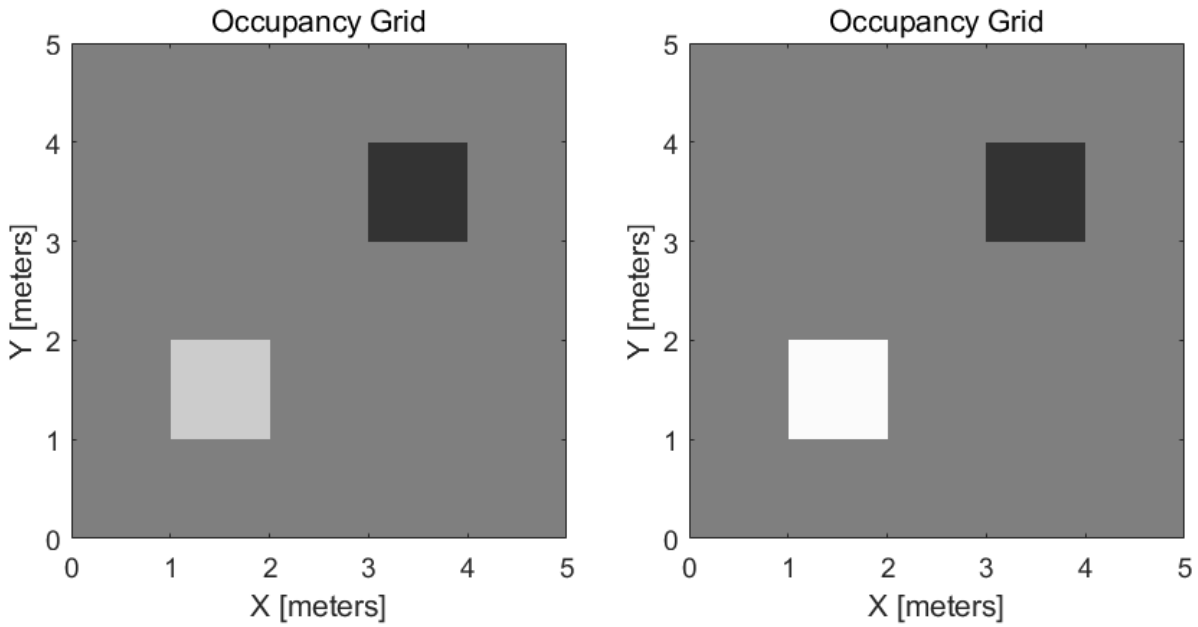
$$p(x) = 1 - \frac{1}{1 + e^{l(x)}}$$



占据栅格地图（Occupancy Grid Map） - 知乎 (zhihu.com) https://zhuanlan.zhihu.com/p/21738718

膨胀占据栅格中的障碍物 Inflate Obstacles in an Occupancy Grid

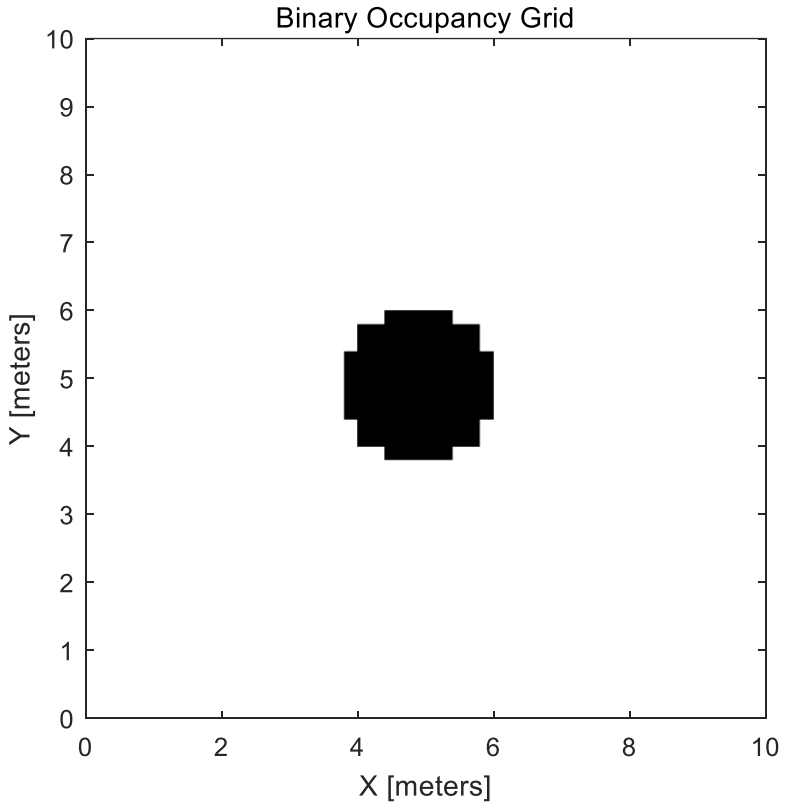
```
map = occupancyMap(5,5,1);
x = [2;4];
y = [2;4];
pvalues = [0.2 0.8];
updateOccupancy(map,[x y],pvalues)
getOccupancy(map,[x(1),y(1)],"local")
ans = 0.2000

tiledlayout(1,2);
nexttile; show(map)

updateOccupancy(map,[x(1) y(1)],pvalues(1));
getOccupancy(map,[x(1),y(1)],"local")
ans = 0.0588
updateOccupancy(map,[x(1) y(1)],pvalues(1));
getOccupancy(map,[x(1),y(1)],"local")
ans = 0.0154
nexttile; show(map)
```

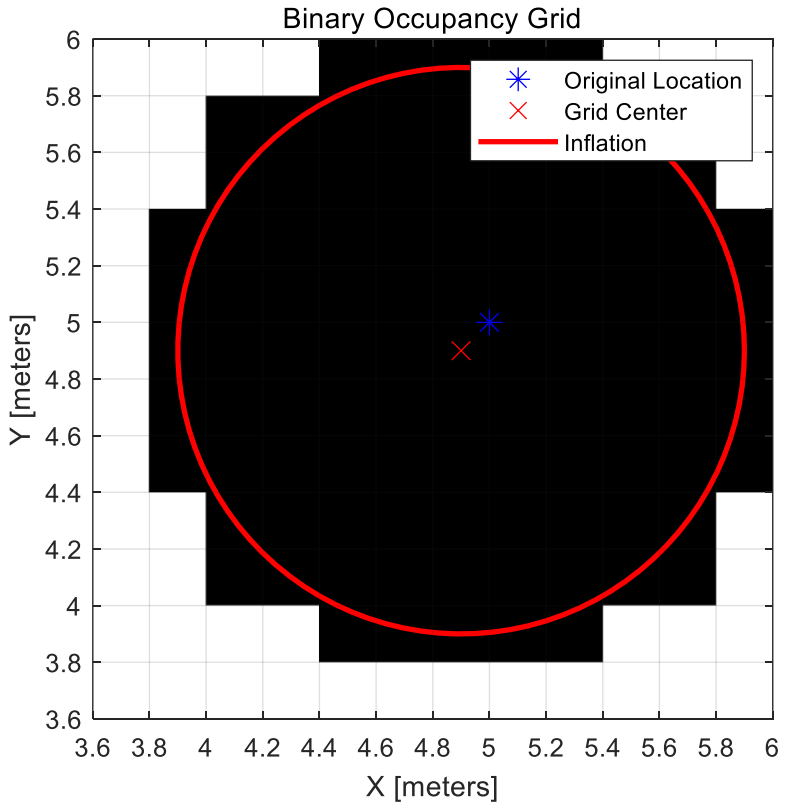


L3=log(2/8*2/8*2/8)
P1=1-1/(1+exp(0-log(0.2/(1-0.8))))
P2=1-1/(1+exp(0-log(4)-log(4)))
P3=1-1/(1+exp(0-log(4)-log(4)-log(4)))
P=1-1/(1+exp(L3))

膨胀二元占用网格中的障碍物

Inflate Obstacles in a Binary Occupancy Grid

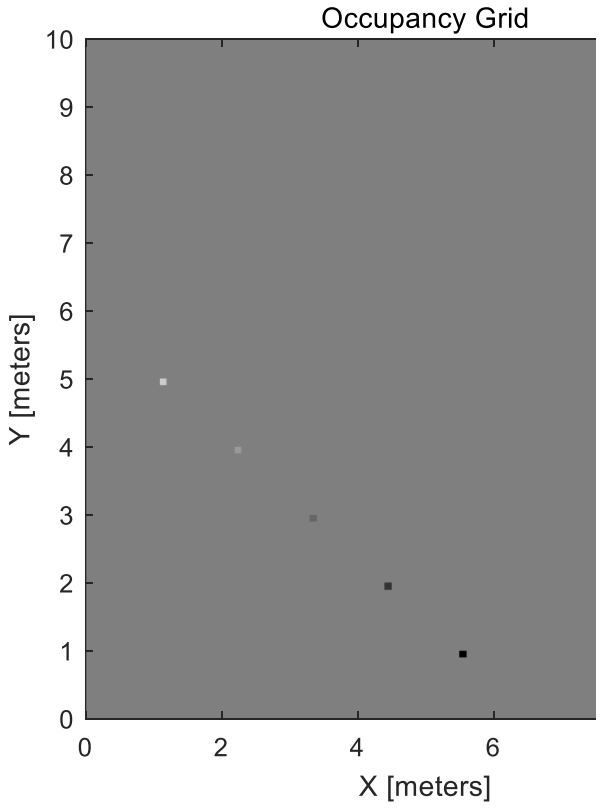


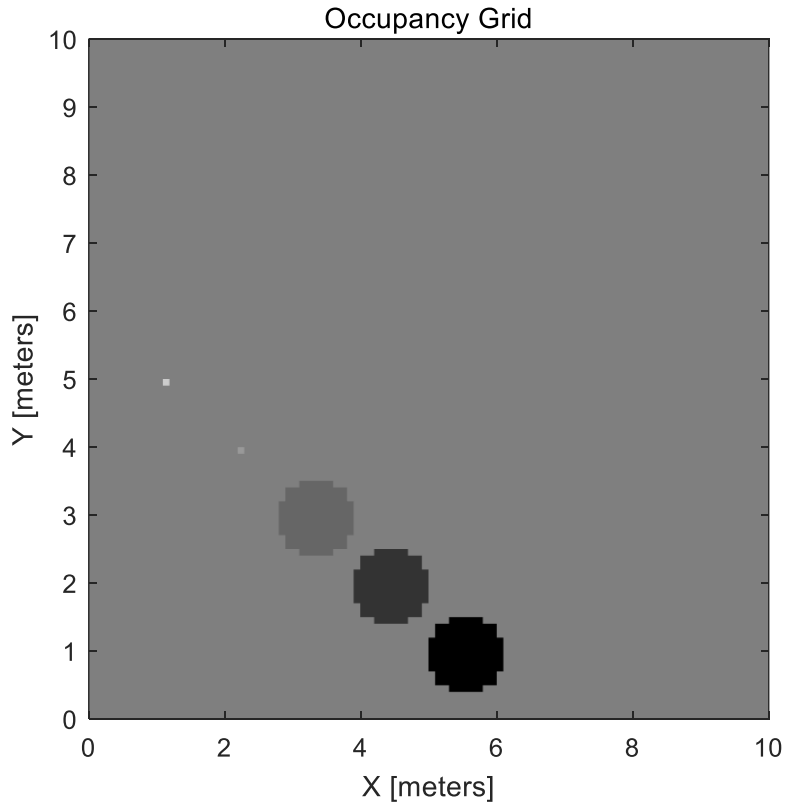


膨胀占用网格中的障碍物

Inflate Obstacles in an Occupancy Grid

```
map = occupancyMap(10,10,10);
x = [1.2; 2.3; 3.4; 4.5; 5.6];
y = [5.0; 4.0; 3.0; 2.0; 1.0];
pvalues = [0.2 0.4 0.6 0.8 1];
updateOccupancy(map,[x y],pvalues)

inflate(map,0.5)
```





inflationCollisionChecker & vehicleCostmap

vehicleCostmap 车辆成本图

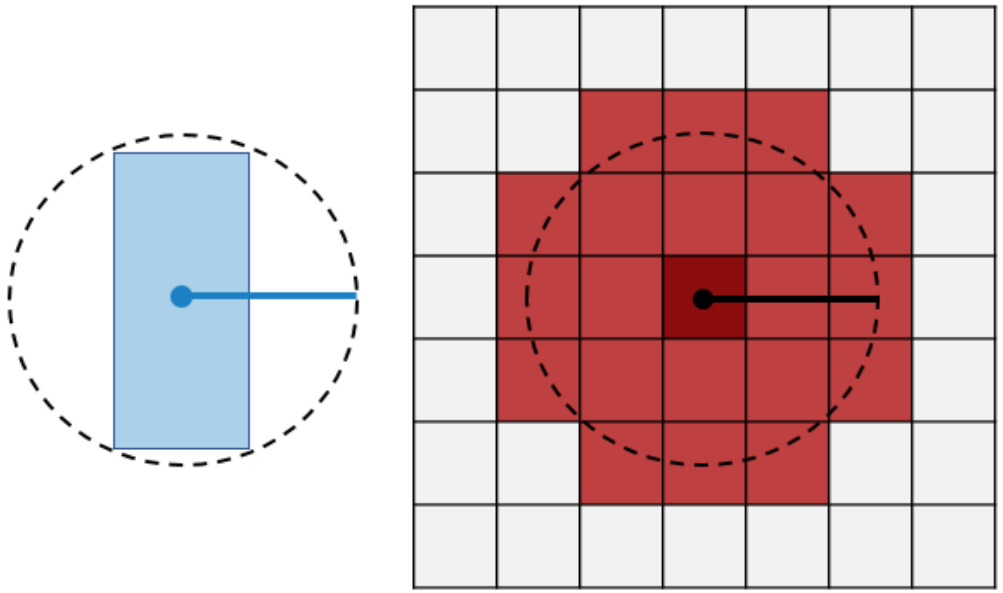
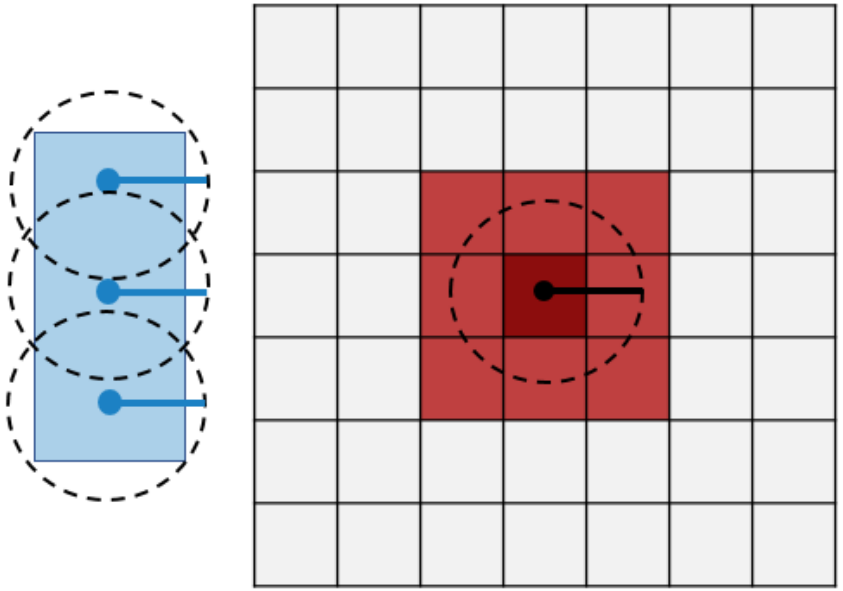
Create and Populate a Vehicle Costmap

inflationCollisionChecker 膨胀碰撞检查器

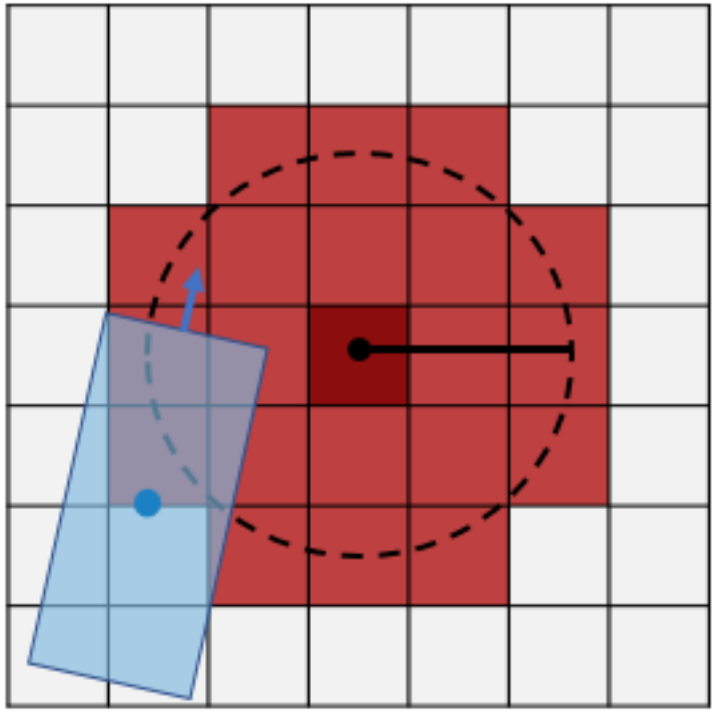
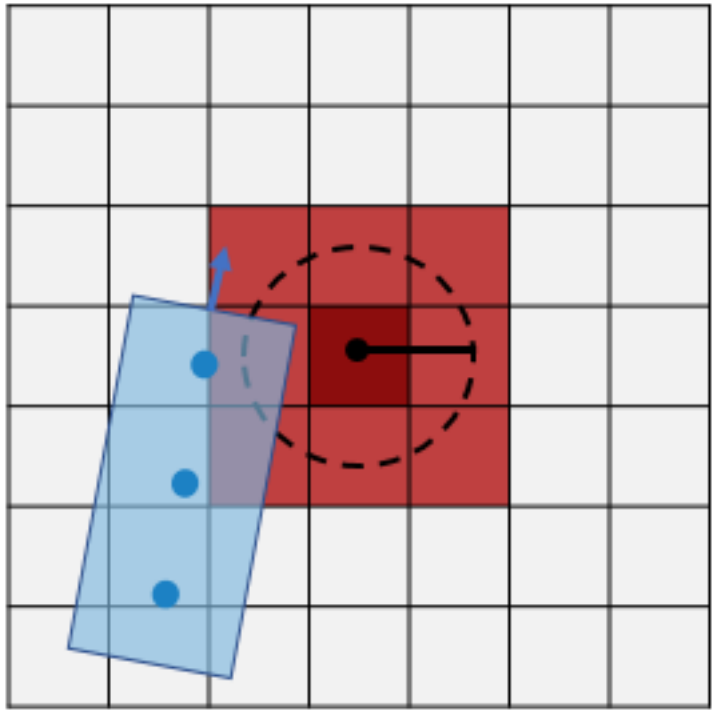
Plan Path Using Different Collision-Checking Configurations

Create Collision-Checking Configuration with Center Placements

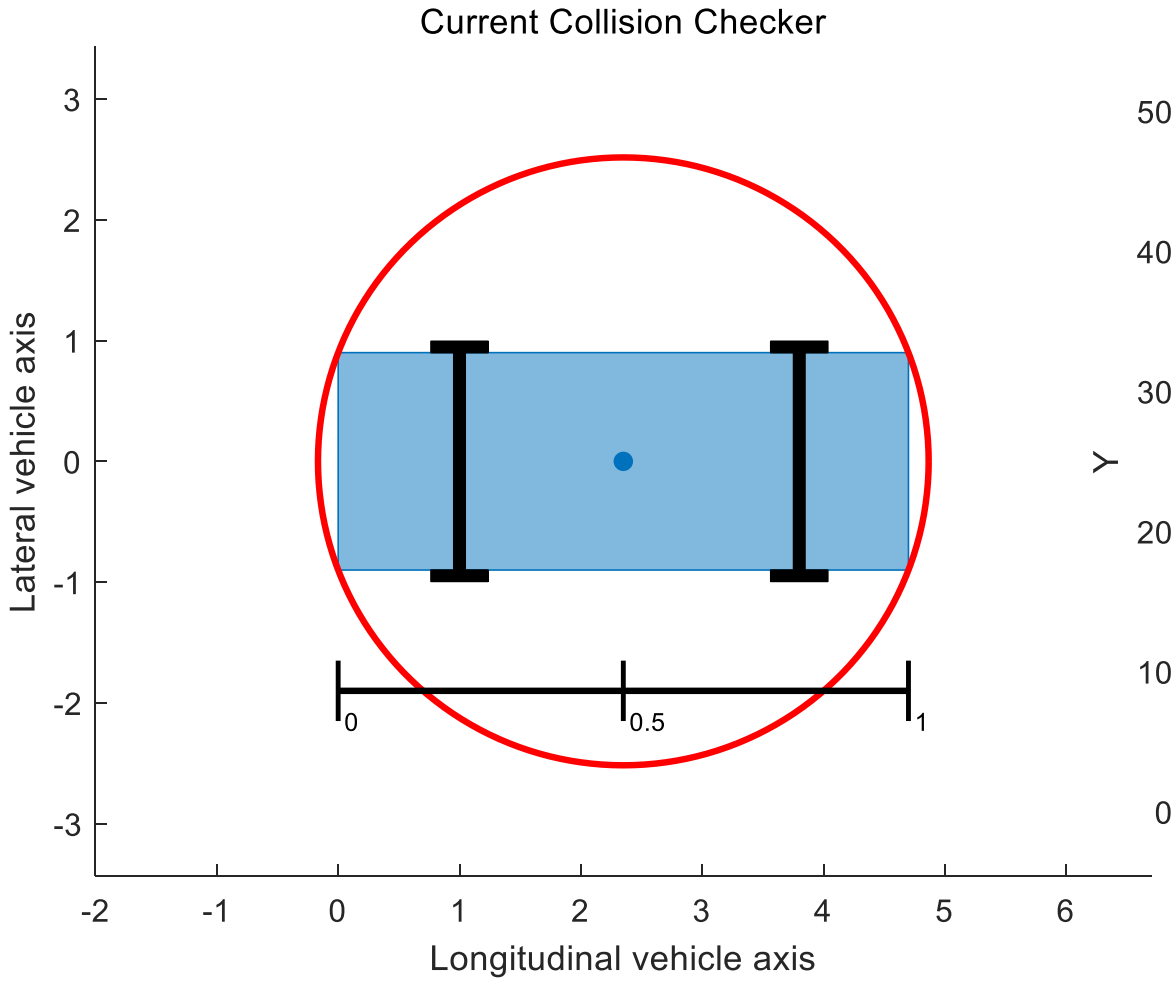
碰撞检查

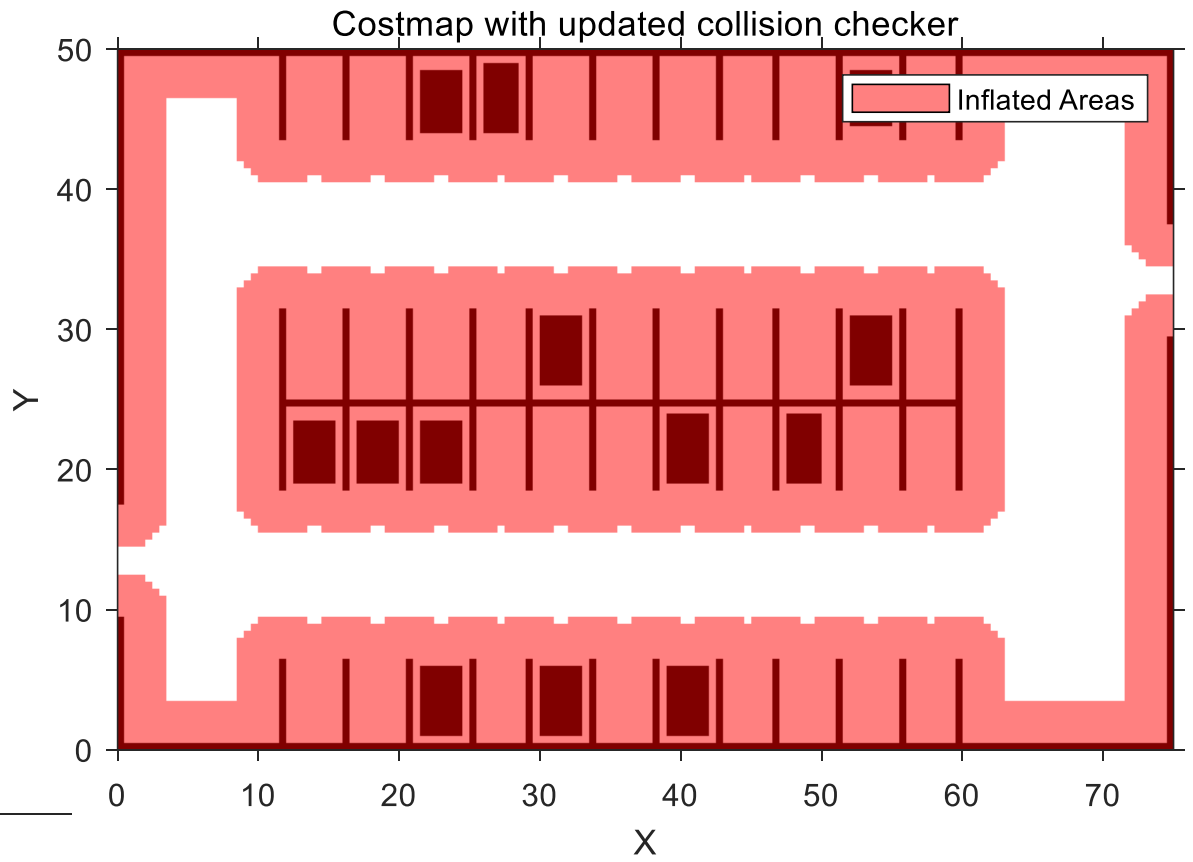
膨胀网络单元，一个中心	膨胀网络单元，三个中心
	

碰撞检查

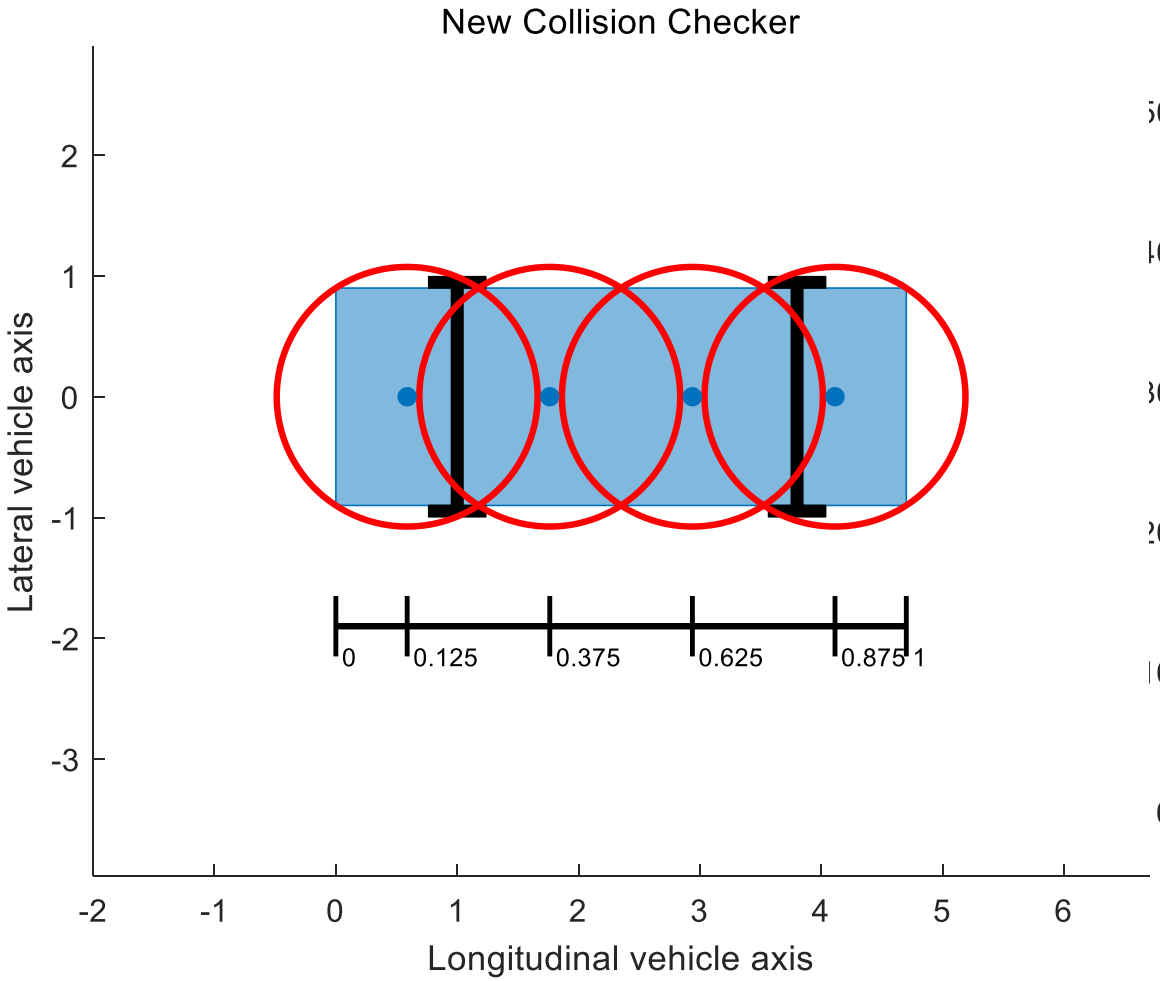
碰撞位姿，一个中心	碰撞位姿，三个中心
	

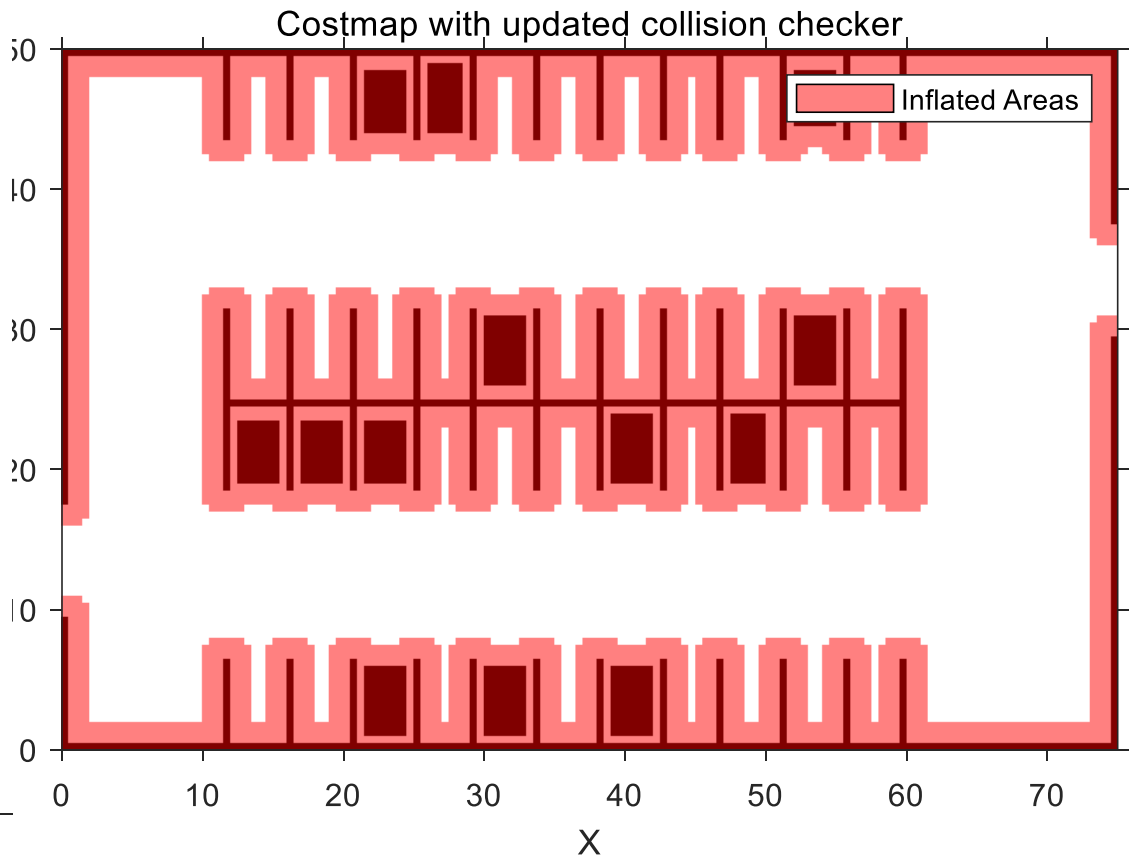
膨胀半径


Current Collision Checker
Lateral vehicle axis
Longitudinal vehicle axis
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
3
4
5
6
0
0.5
1


Costmap with updated collision checker
Inflated Areas
Y
X
50
40
30
20
10
0
0
10
20
30
40
50
60
70

膨胀半径


New Collision Checker
Lateral vehicle axis
Longitudinal vehicle axis
2
1
0
-1
-2
-3
-2
-1
0
1
2
3
4
5
6
0
0.125
0.375
0.625
0.875
1

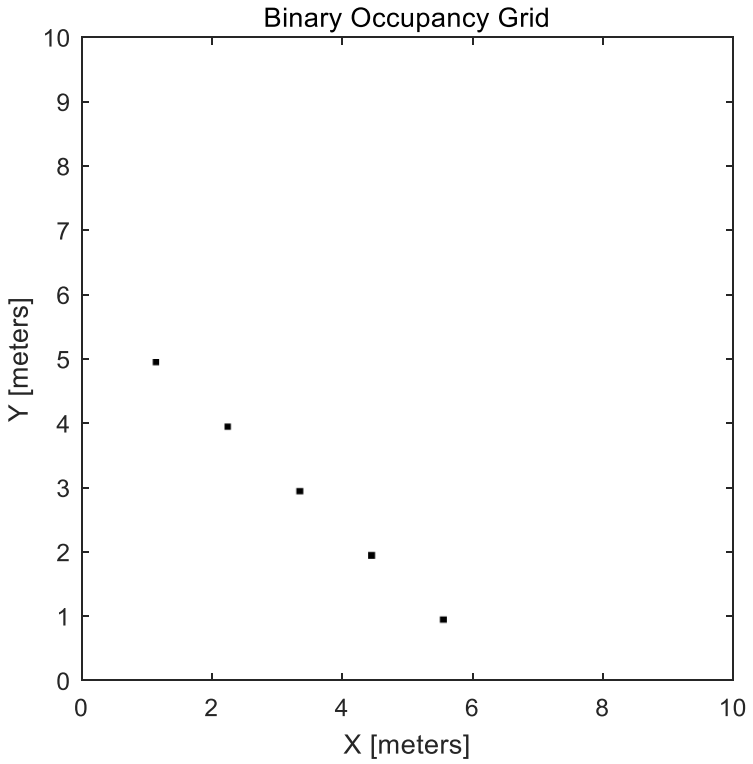

Costmap with updated collision checker
Inflated Areas
X
0
10
20
30
40
50
60
70

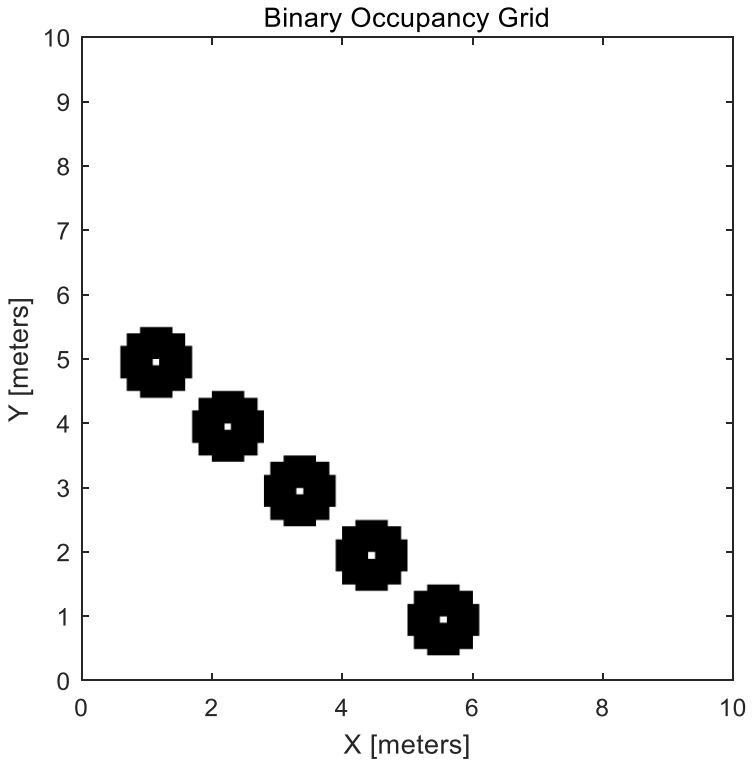
膨胀：inflate

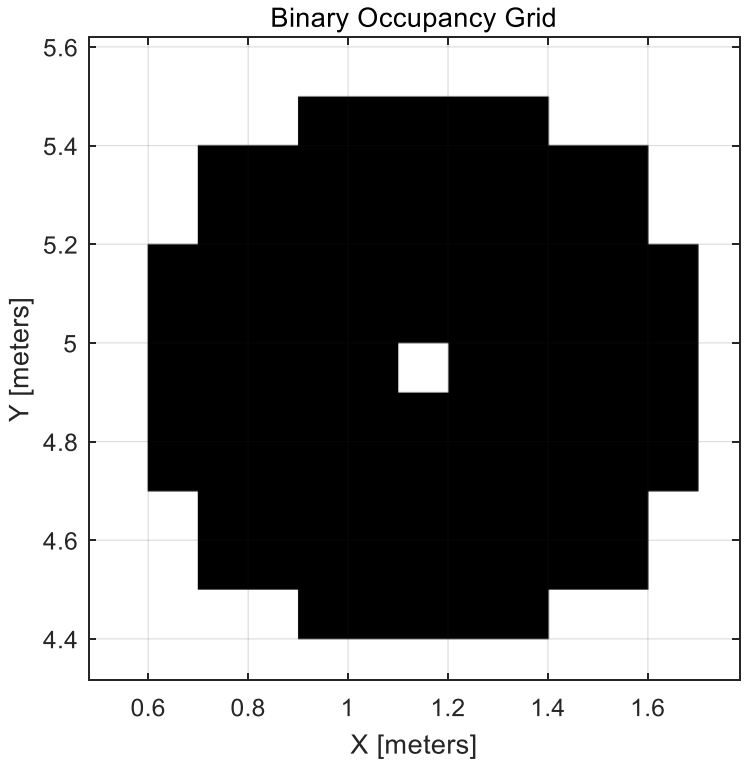
Create and Modify Binary Occupancy Grid

```
map = binaryOccupancyMap(10,10,10);
x = [1.2; 2.3; 3.4; 4.5; 5.6];
y = [5.0; 4.0; 3.0; 2.0; 1.0];
setOccupancy(map, [x y], ones(5,1))
```

```
inflate(map, 0.5)
setOccupancy(map, [x y], zeros(5,1))
```



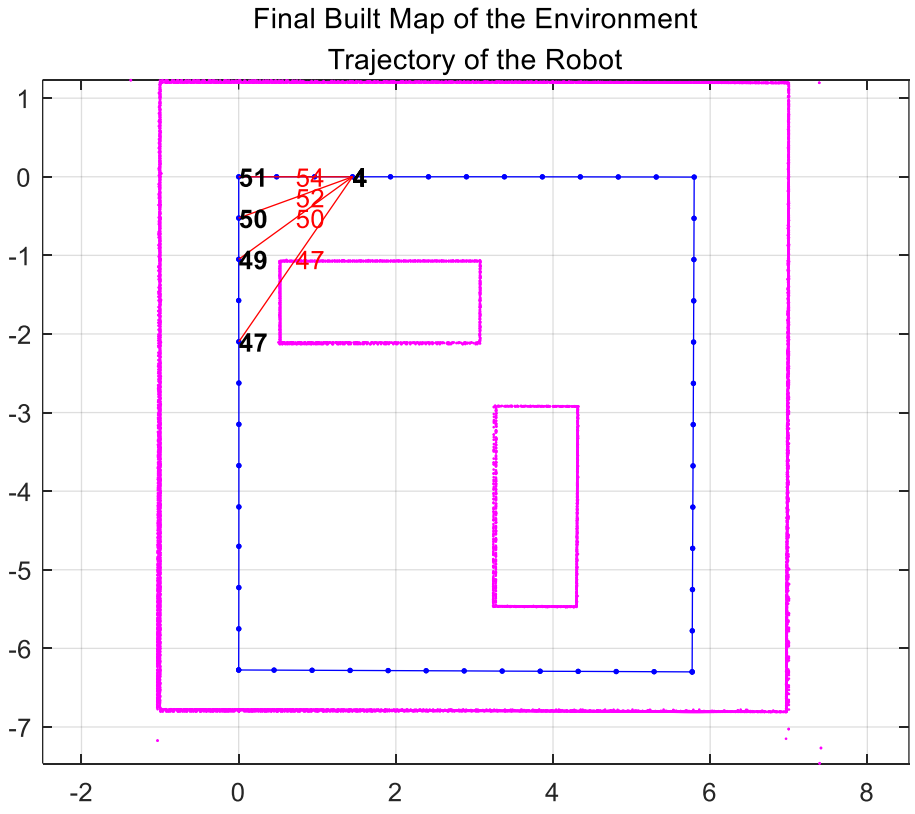




使用激光雷达扫描实施在线SLAM

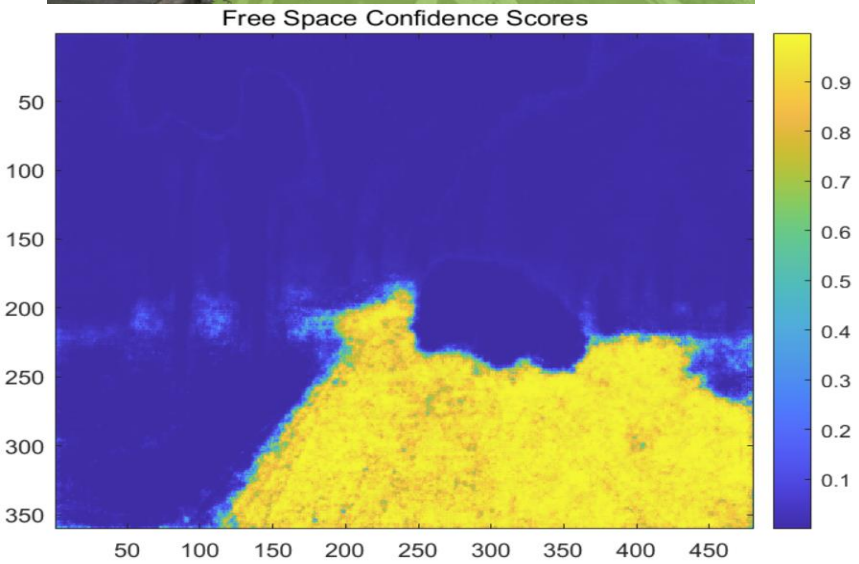
完整2dSLAM,
模拟 单线激光雷达

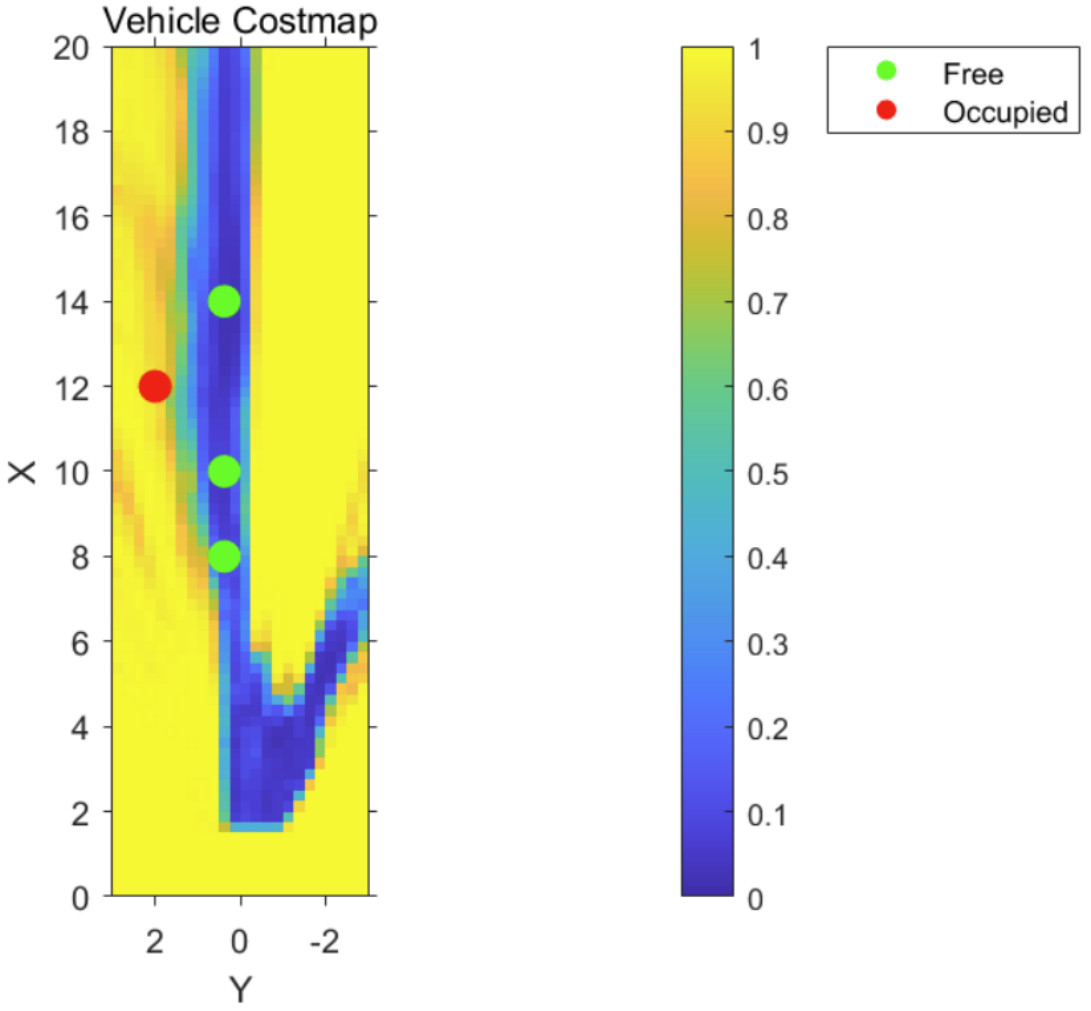
Implement Online Simultaneous Localization And Mapping (SLAM) with Lidar Scans



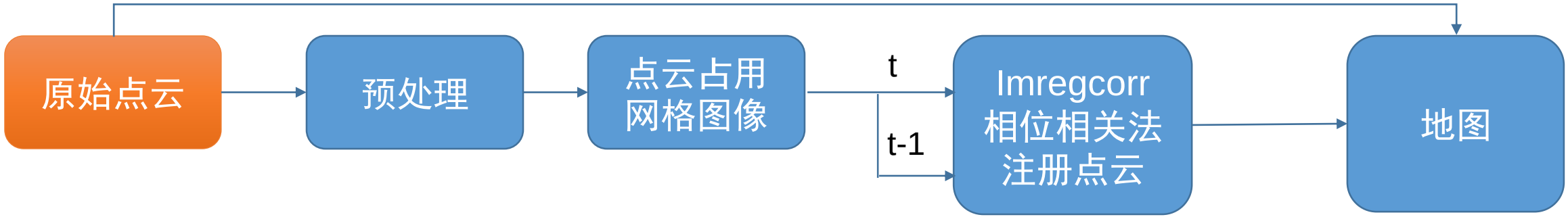
使用单目摄像头和语义分割创建占据栅格

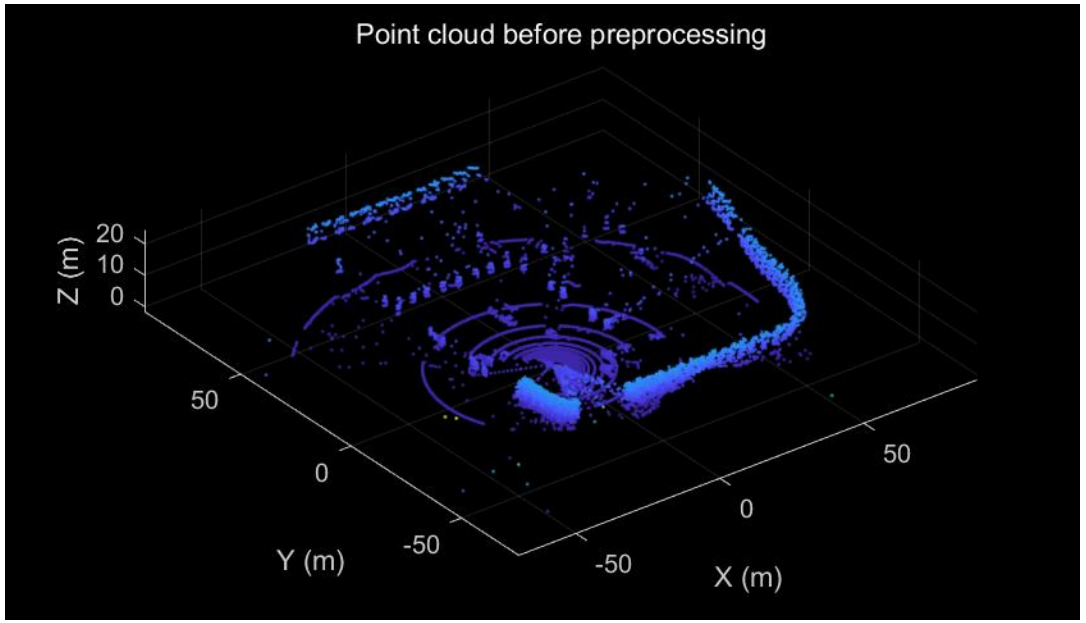
Create Occupancy Grid Using Monocular Camera and Semantic Segmentation





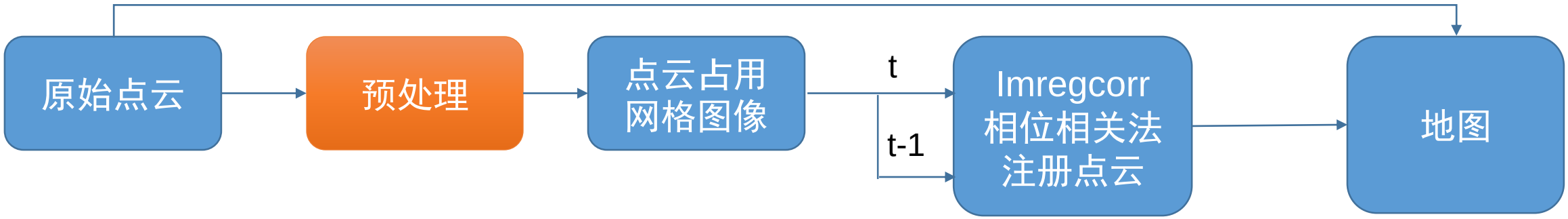
3D激光雷达SLAM构建占用地图

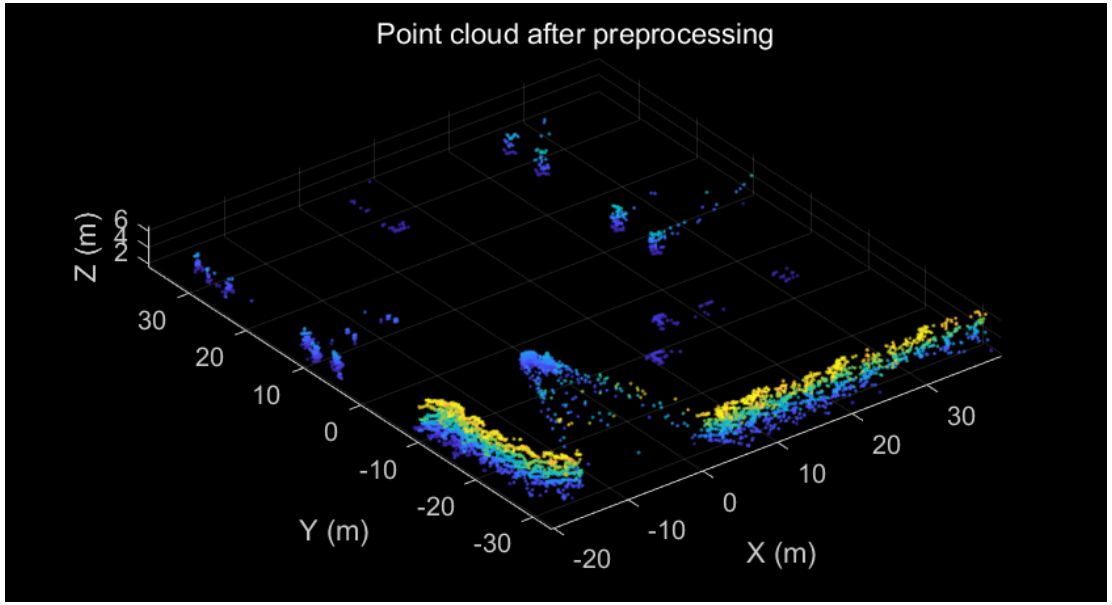


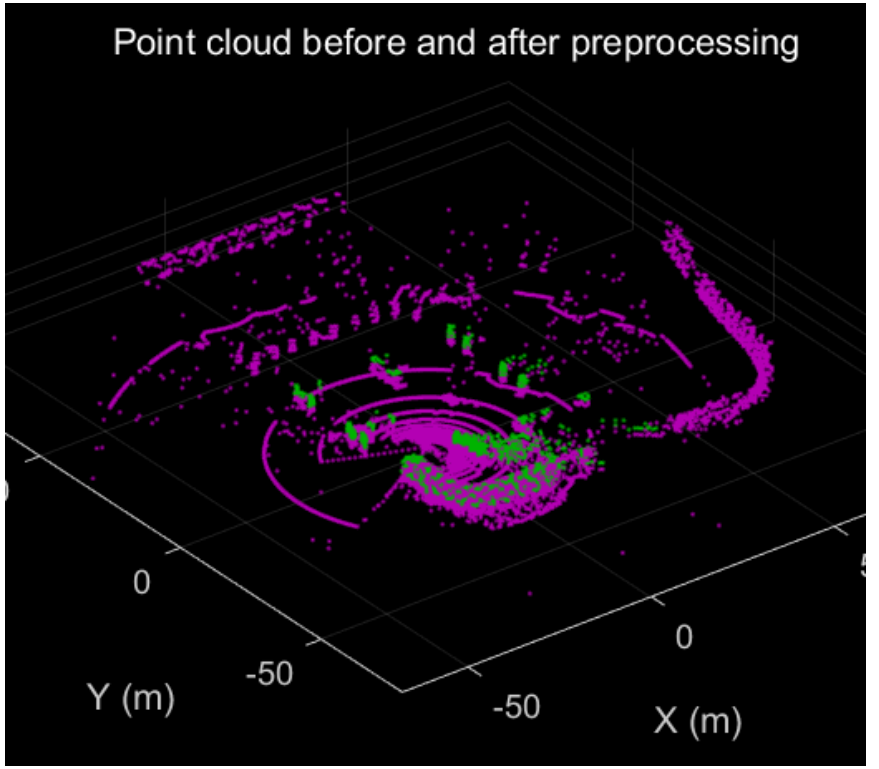


Build Occupancy Map from 3-D Lidar Data Using SLAM

3D激光雷达SLAM构建占用地图

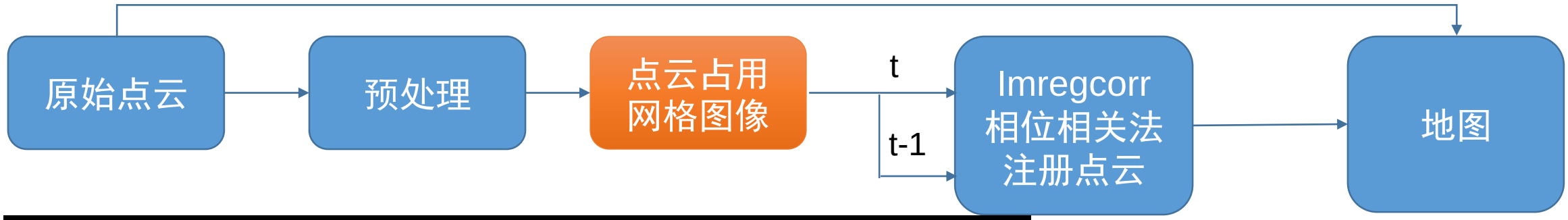


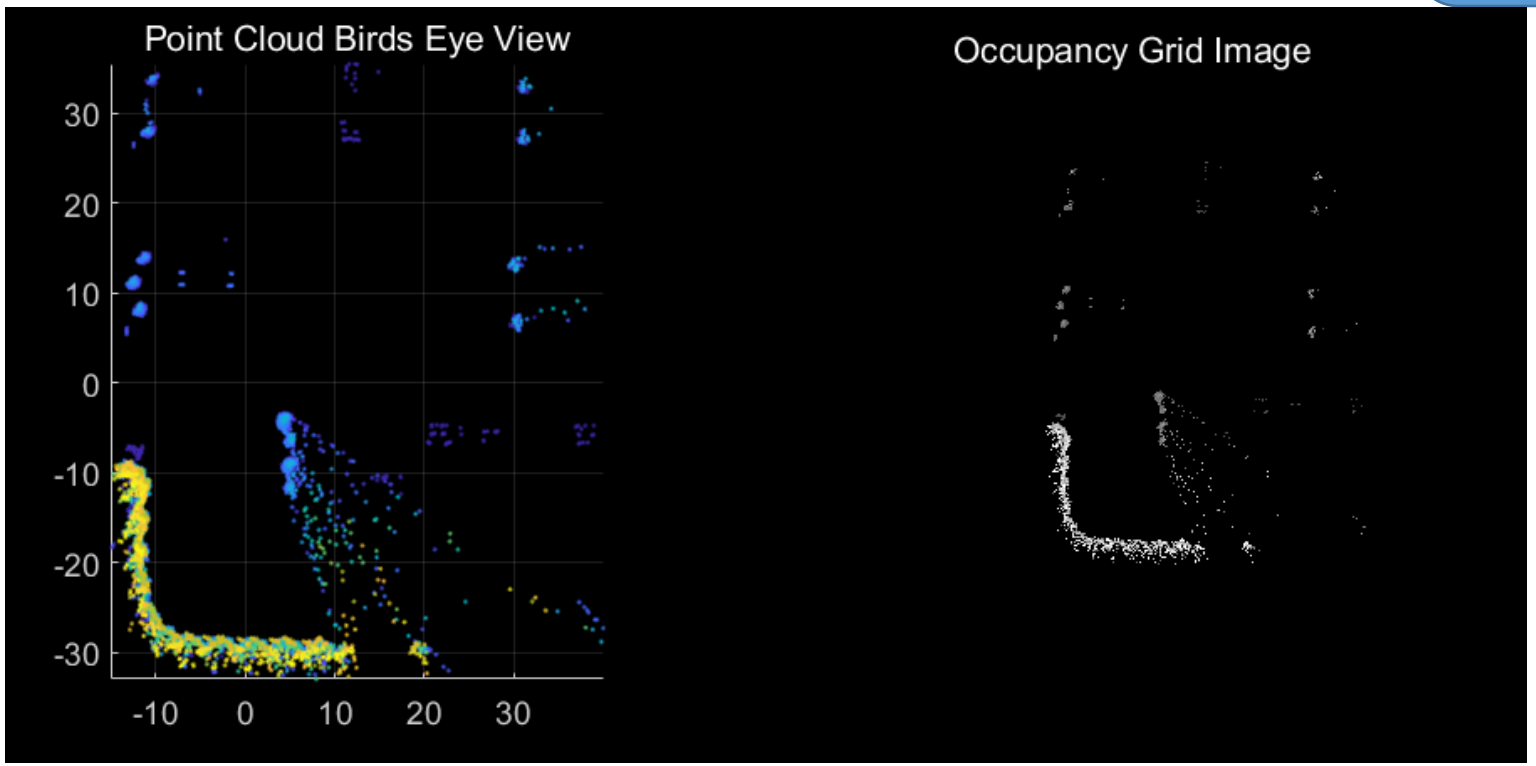




Build Occupancy Map from 3-D Lidar Data Using SLAM

3D激光雷达SLAM构建占用地图





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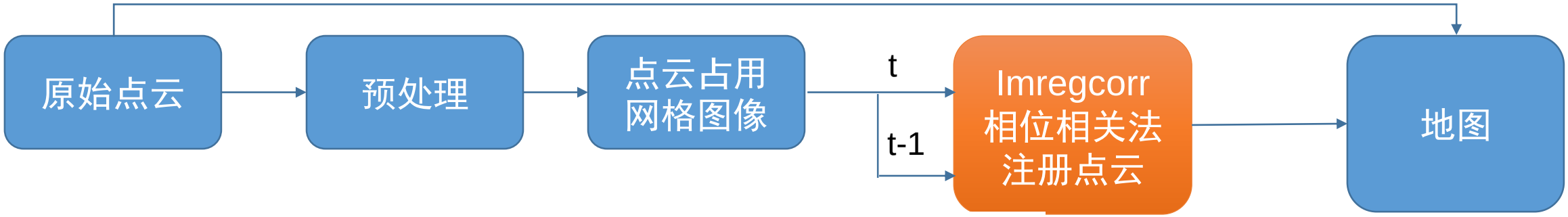
3D激光雷达SLAM构建占用地图



$f_1(x,y), f_2(x,y)$是两幅图像信号，且$f_2(x,y)$是由$f_1(x,y)$平移(dx,dy)得到的，即满足如下：

$$f_2(x,y) = f_1(x-dx, y-dy)$$

将其反映到频域，其形式为：

$$F_2(u,v) = F_1(u,v) \cdot e^{-i\cdot 2\pi\cdot(u\cdot dx + v\cdot dy)}$$

将左边除以右边，得到互功率谱，其形式如下：

互功率谱 $$H(u,v) = \frac{F_1 \cdot F_2^*}{|A_1| \cdot |A_2^*|} = e^{-i\cdot 2\pi\cdot(u\cdot dx + v\cdot dy)}$$

狄拉克函数 $$IFFT(H(u,v)) = \delta(u-dx, v-dy)$$

$$\max(\delta) \rightarrow dx_{offset}, dy_{offset}$$

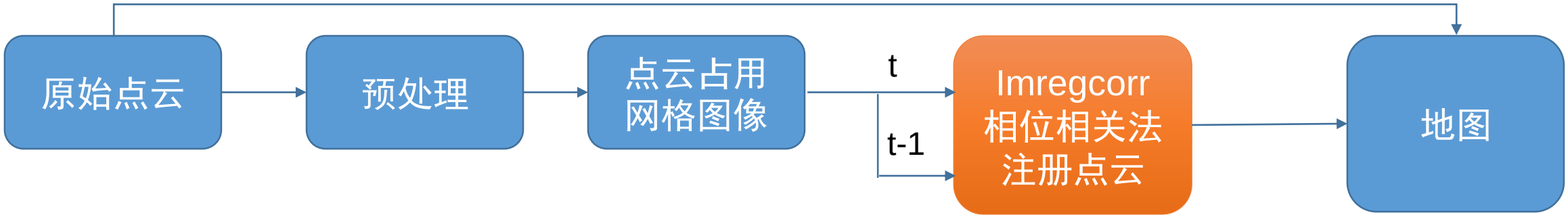
于是对互功率谱做傅里叶反变换可得到一个狄拉克函数（脉冲函数），通过寻找这个峰值的坐标即可找到偏移量

```
function d = phasecorr(A,B)
size_A  = size(A);
size_B  = size(B);
outSize = size_A + size_B - 1;
A = fft2(A,outSize(1),outSize(2));
B = fft2(B,outSize(1),outSize(2));
ABConj = A .* conj(B);
d = ifft2(ABConj ./ abs(eps+ABConj),'symmetric');
```


[1] Dimitrievski, Martin, David Van Hamme, Peter Veelaert, and Wilfried Philips. “Robust Matching of Occupancy Maps for Odometry in Autonomous Vehicles.” In *Proceedings of the 11th Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*, 626–33. Rome, Italy: SCITEPRESS - Science and Technology Publications, 2016.

Build Occupancy Map from 3-D Lidar Data Using SLAM

3D激光雷达SLAM构建占用地图

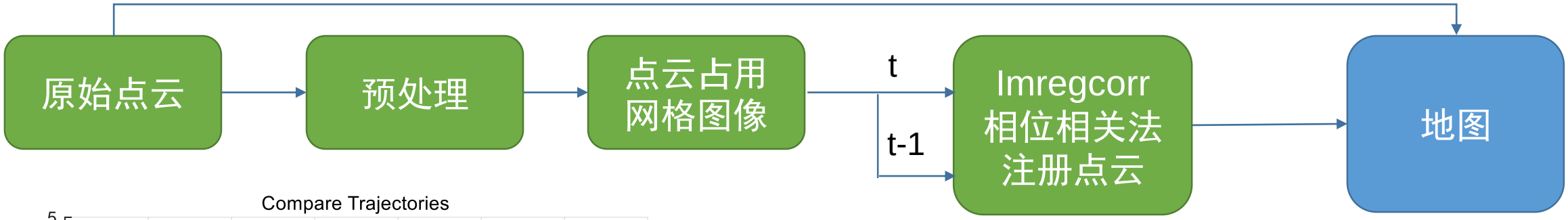


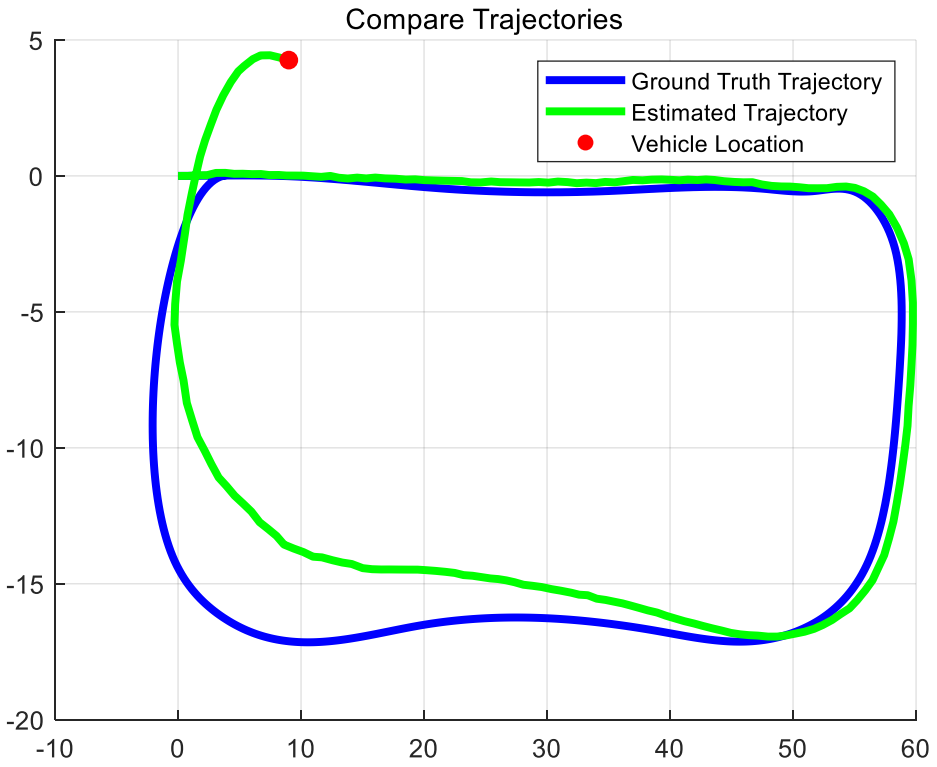

```
function [tform, peak] = findSimilarity(moving,fixed,windowing)
[M,F] = getFourierMellinSpectra(moving,fixed,windowing);
thetaRange = [0 pi];
Fpolar = images.internal.LogPolar(F,thetaRange);
Mpolar = images.internal.LogPolar(M,thetaRange);

Fpolar.resampledImage = manageWindowing(Fpolar.resampledImage,windowing
Mpolar.resampledImage = manageWindowing(Mpolar.resampledImage,windowing);
d = phasecorr(Fpolar.resampledImage,Mpolar.resampledImage);
```

[1] Dimitrievski, Martin, David Van Hamme, Peter Veelaert, and Wilfried Philips. “Robust Matching of Occupancy Maps for Odometry in Autonomous Vehicles.” In *Proceedings of the 11th Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*, 626–33. Rome, Italy: SCITEPRESS - Science and Technology Publications, 2016.

Build Occupancy Map from 3-D Lidar Data Using SLAM

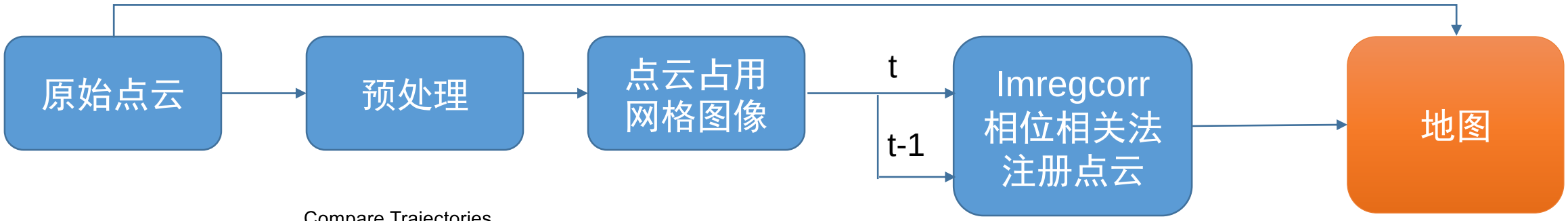
3D激光雷达SLAM构建占用地图

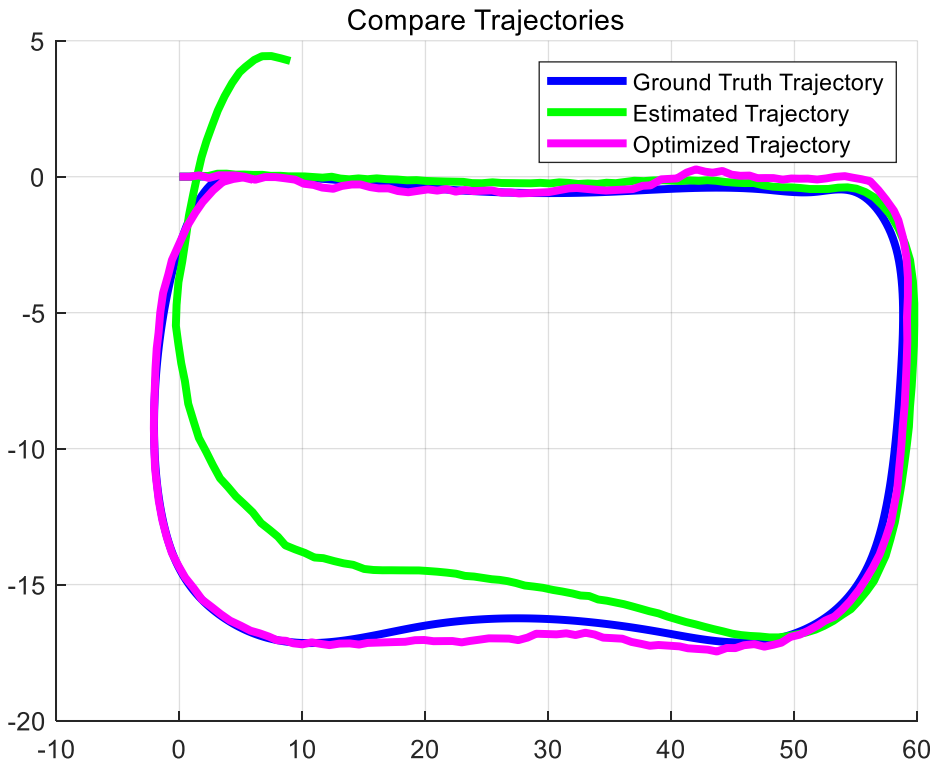


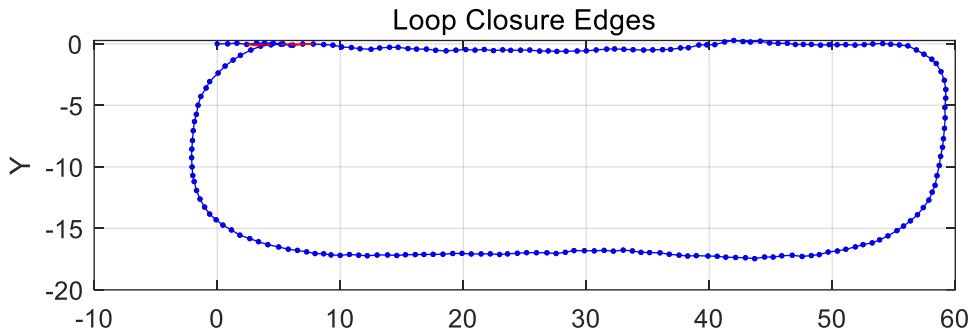


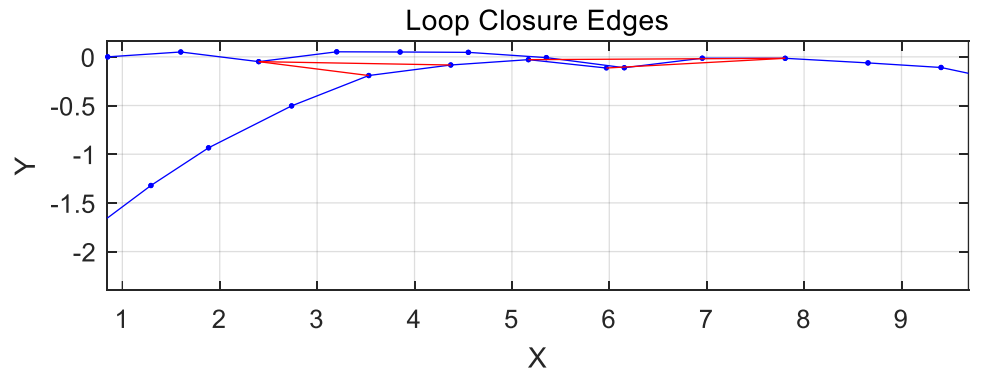
Build Occupancy Map from 3-D Lidar Data Using SLAM

3D激光雷达SLAM构建占用地图



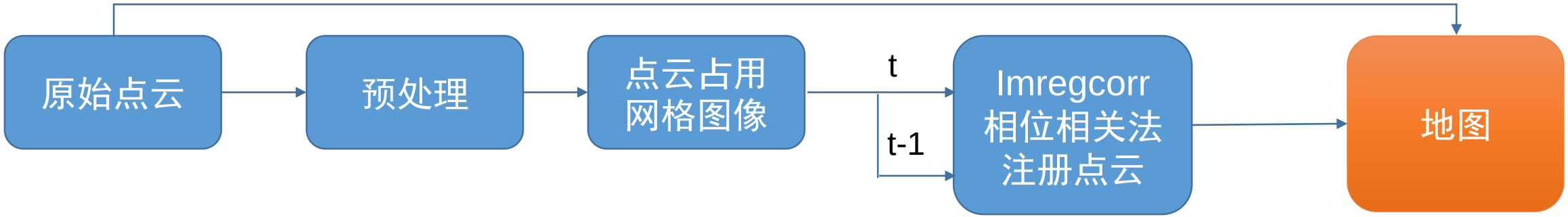


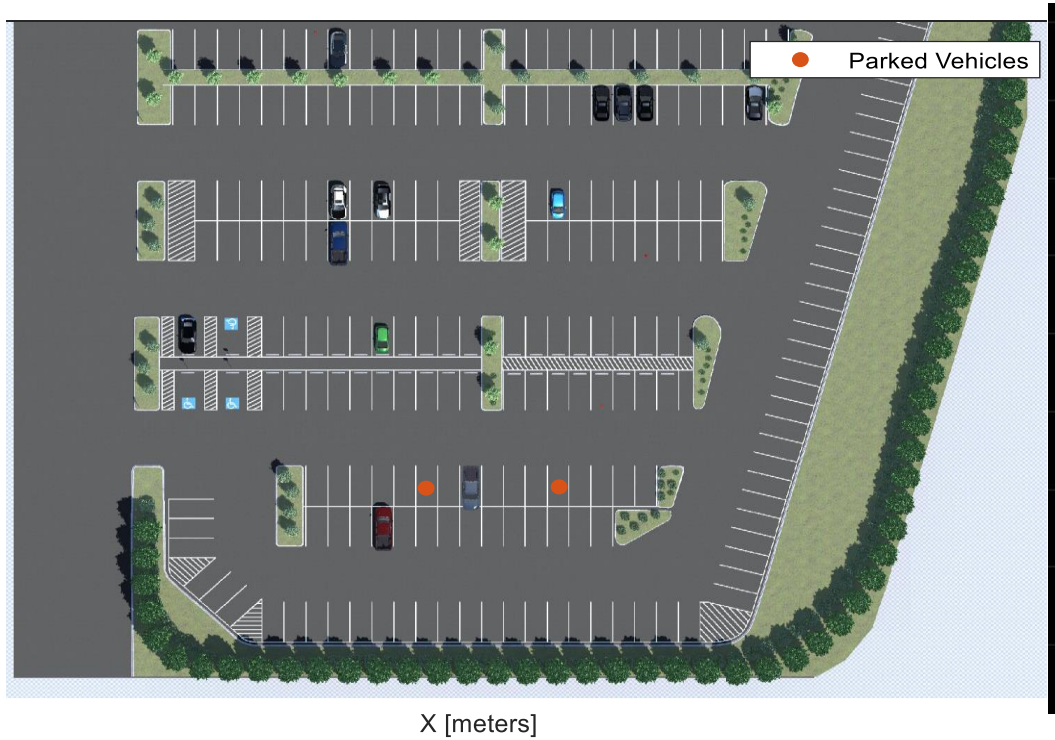


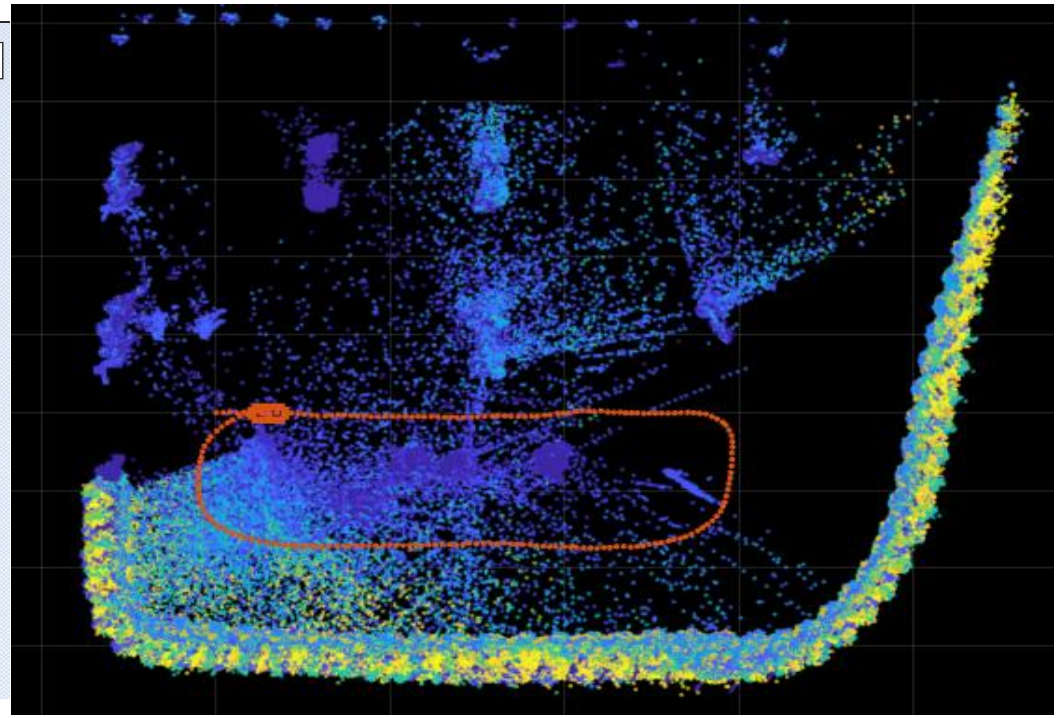


Build Occupancy Map from 3-D Lidar Data Using SLAM

3D激光雷达SLAM构建占用地图

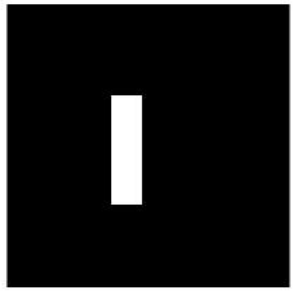
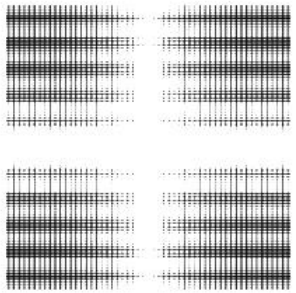
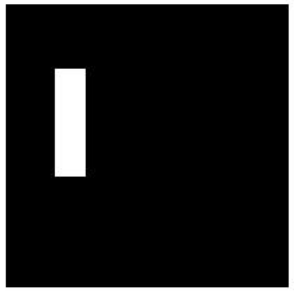
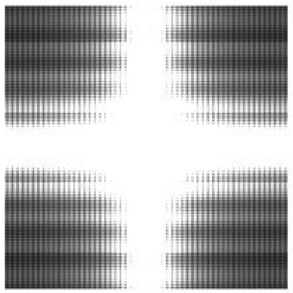
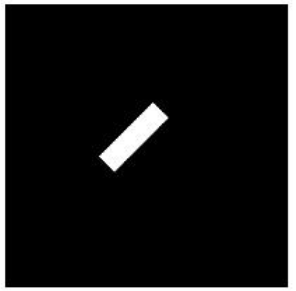
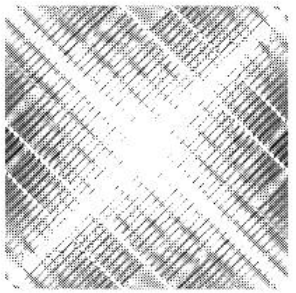


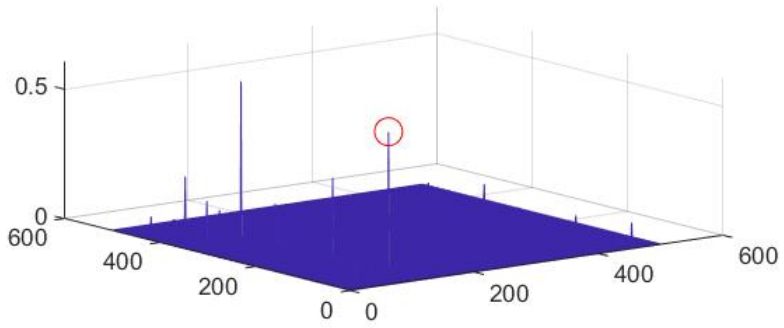


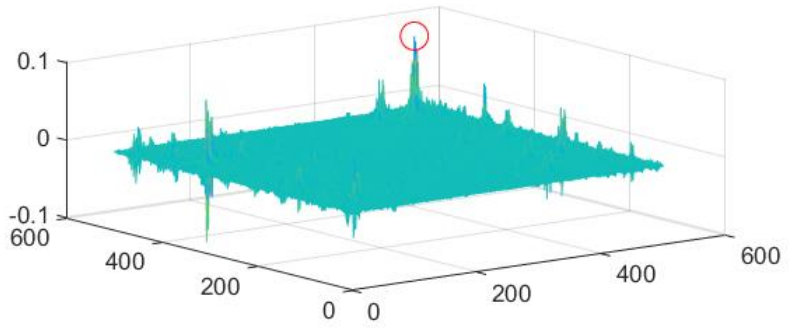


Build Occupancy Map from 3-D Lidar Data Using SLAM

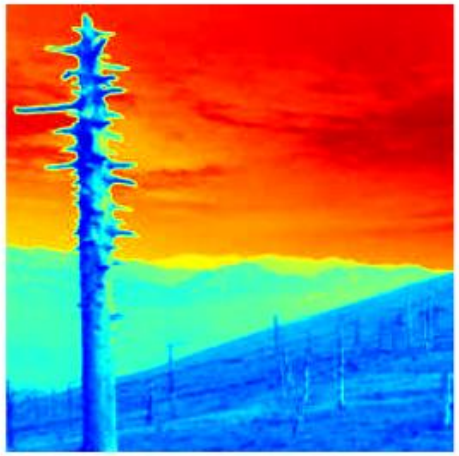
相位相关法

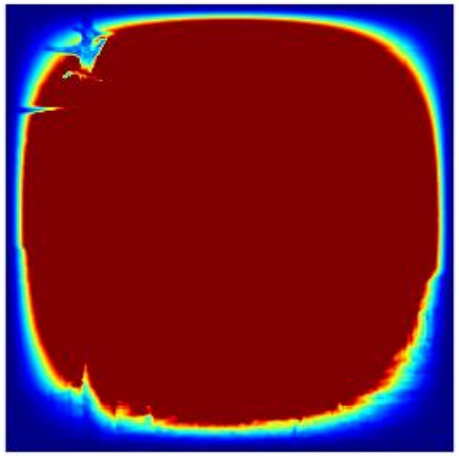







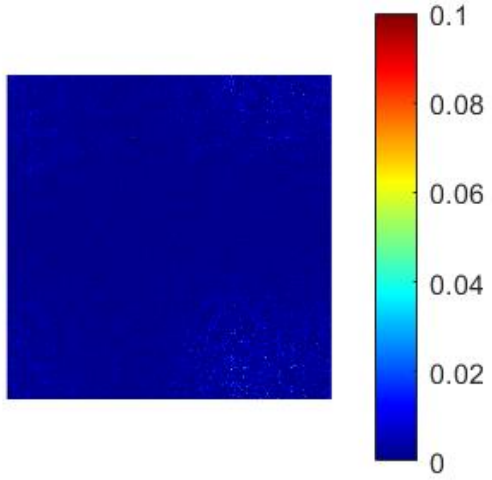




相位相关法



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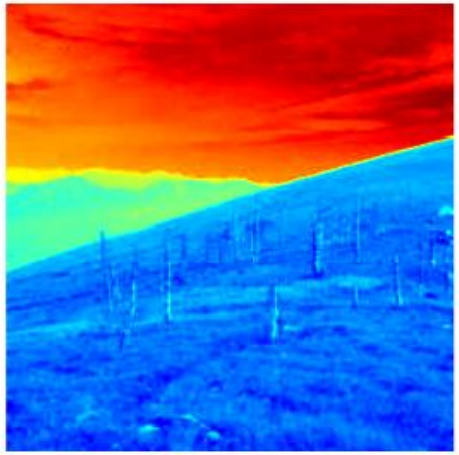

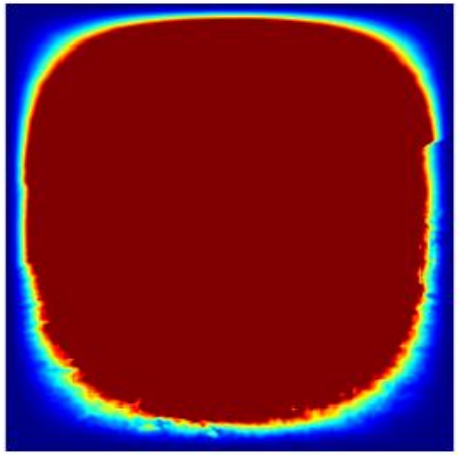

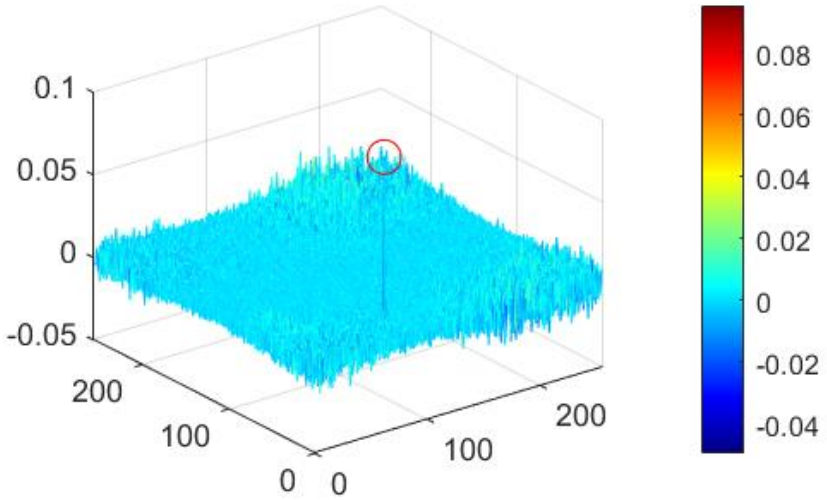
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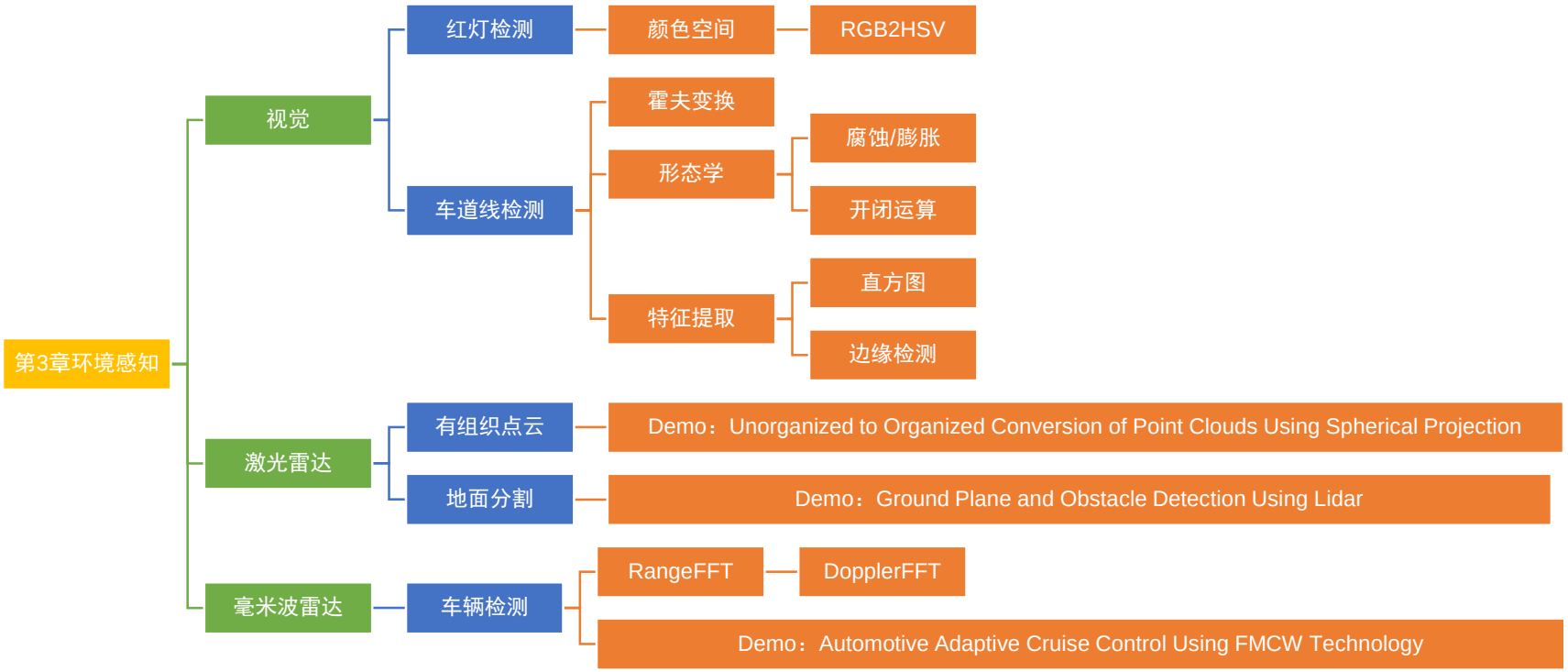
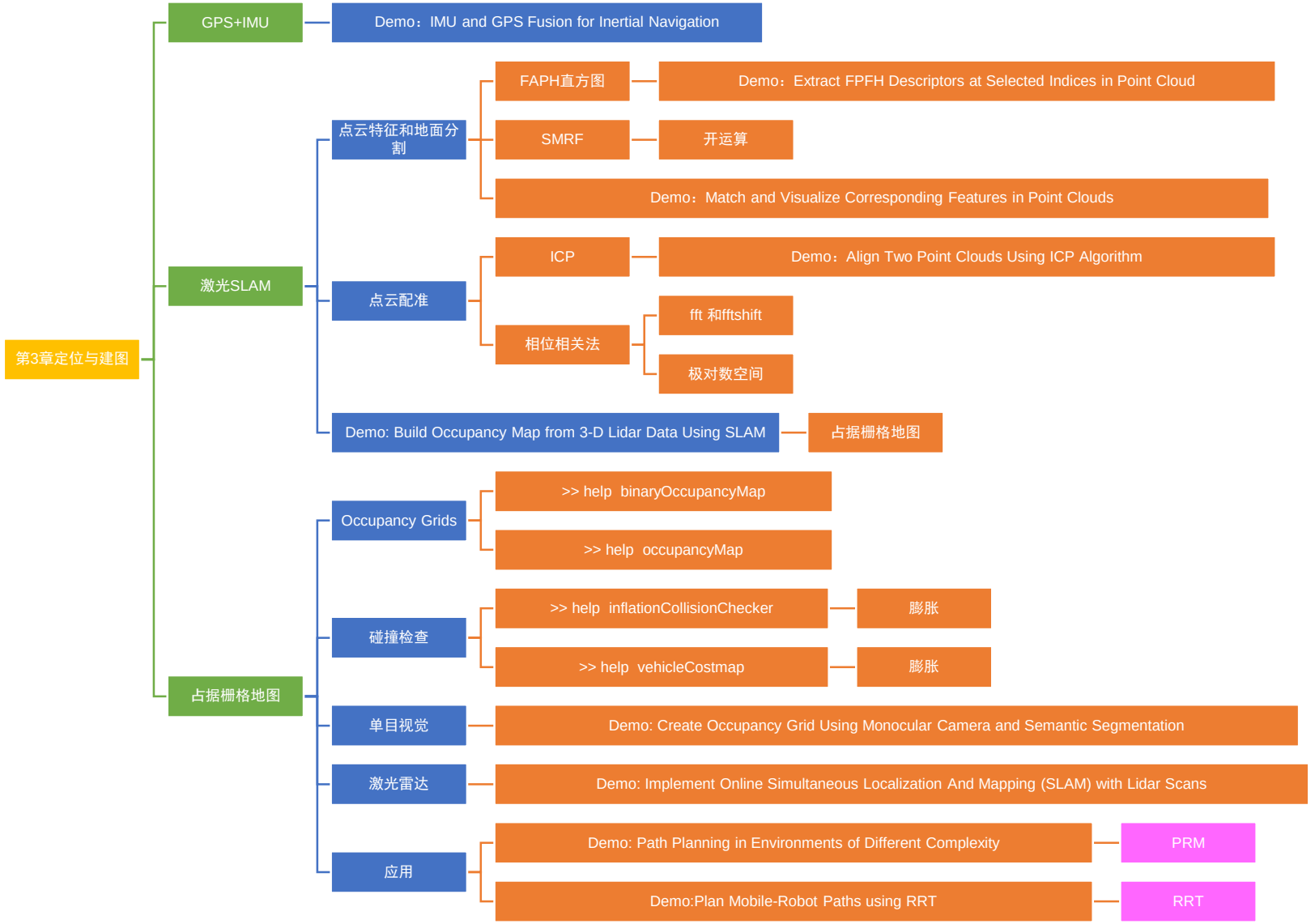
知识点梳理


第3章环境感知
视觉
红灯检测
颜色空间
RGB2HSV
车道线检测
霍夫变换
形态学
腐蚀/膨胀
开闭运算
特征提取
直方图
边缘检测
激光雷达
有组织点云
Demo：Unorganized to Organized Conversion of Point Clouds Using Spherical Projection
地面分割
Demo：Ground Plane and Obstacle Detection Using Lidar
毫米波雷达
车辆检测
RangeFFT
DopplerFFT
Demo：Automotive Adaptive Cruise Control Using FMCW Technology

知识点梳理


第3章定位与建图
GPS+IMU
Demo：IMU and GPS Fusion for Inertial Navigation
激光SLAM
点云特征和地面分割
FAPH直方图
Demo：Extract FPFH Descriptors at Selected Indices in Point Cloud
SMRF
开运算
Demo：Match and Visualize Corresponding Features in Point Clouds
点云配准
ICP
Demo：Align Two Point Clouds Using ICP Algorithm
相位相关法
fft 和fftshift
极对数空间
Demo: Build Occupancy Map from 3-D Lidar Data Using SLAM
占据栅格地图
占据栅格地图
Occupancy Grids
>> help binaryOccupancyMap
>> help occupancyMap
碰撞检查
>> help inflationCollisionChecker
膨胀
>> help vehicleCostmap
膨胀
单目视觉
Demo: Create Occupancy Grid Using Monocular Camera and Semantic Segmentation
激光雷达
Demo: Implement Online Simultaneous Localization And Mapping (SLAM) with Lidar Scans
应用
Demo: Path Planning in Environments of Different Complexity
PRM
Demo:Plan Mobile-Robot Paths using RRT
RRT

感谢聆听！