Automatic Map Building and SLAM with Object Recognition Report

ORB-SLAM2 Extension

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July 28, 2017

Outline

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Motion Planning Algorithms

- Sampling-Based Motion Planning
  - Randomly explore a smaller subset of possibilities rather than exhaustively explore all possibilities
  - Apply easily to high-dimensional and continuous C-space
  - Run fast
  - Unlikely to sample nodes in narrow passages
  - Sometimes result in unusual looking and possibly inefficient paths

  Example: PRM, RRT, RRTConnect, RRT*

  Library: OMPL
- Search-Based Motion Planning
  - Guarantee an efficient solution
  - Take more computation time

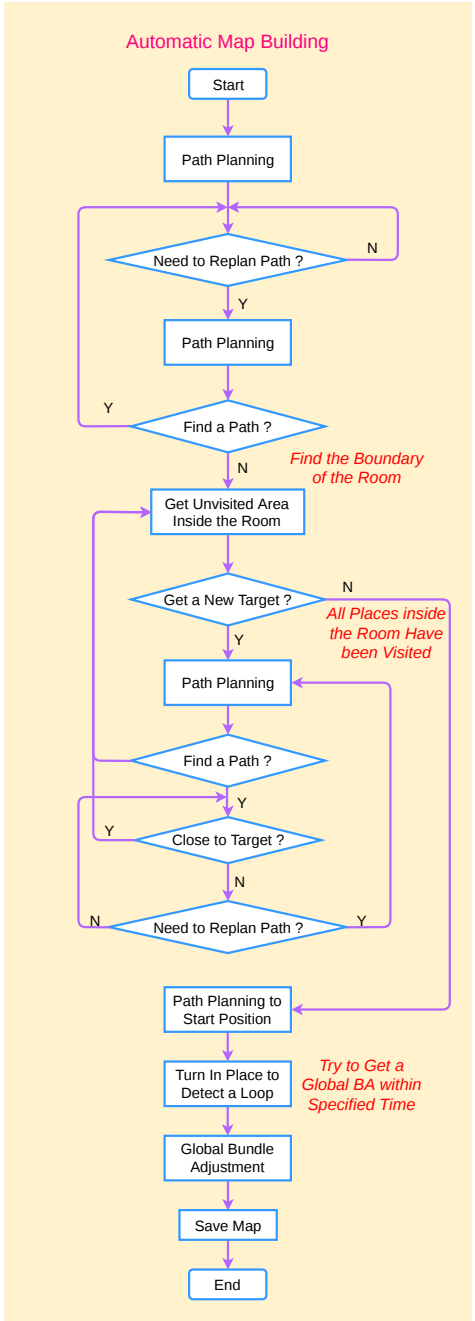
  Example: Dijkstra search, A*, D*, ARA*, AD*, D* Lite

  Library: SBPL

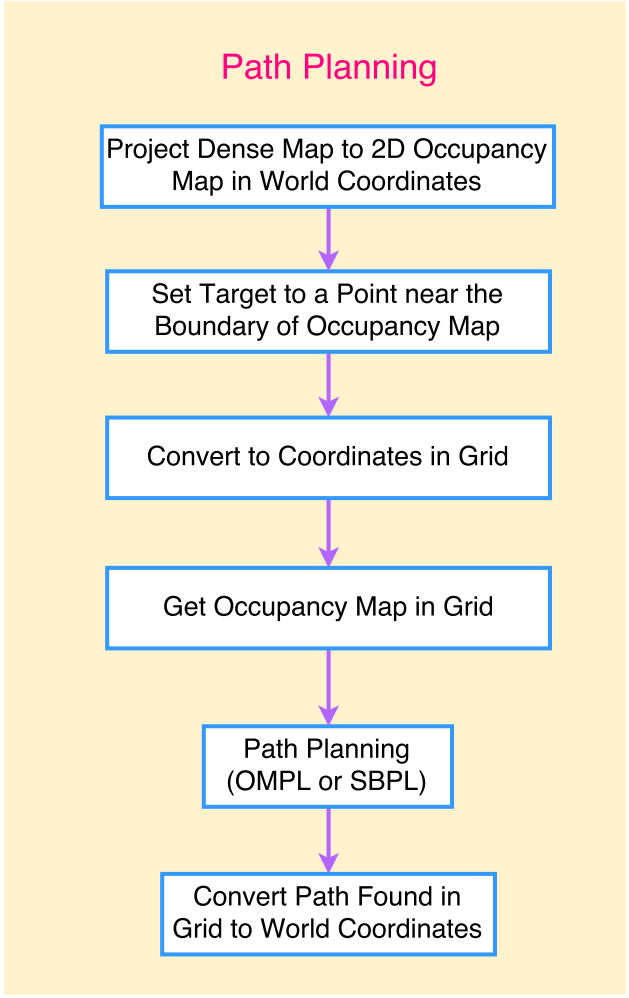
Automatic Map Exploration

- Keyidea: Use motion planning algorithms to find a path from robot's current position to a target position that's near (but outside of) the boundary of current occupancy map
  - No path found $\Longrightarrow$ boundary closed

Automatic Map Exploration



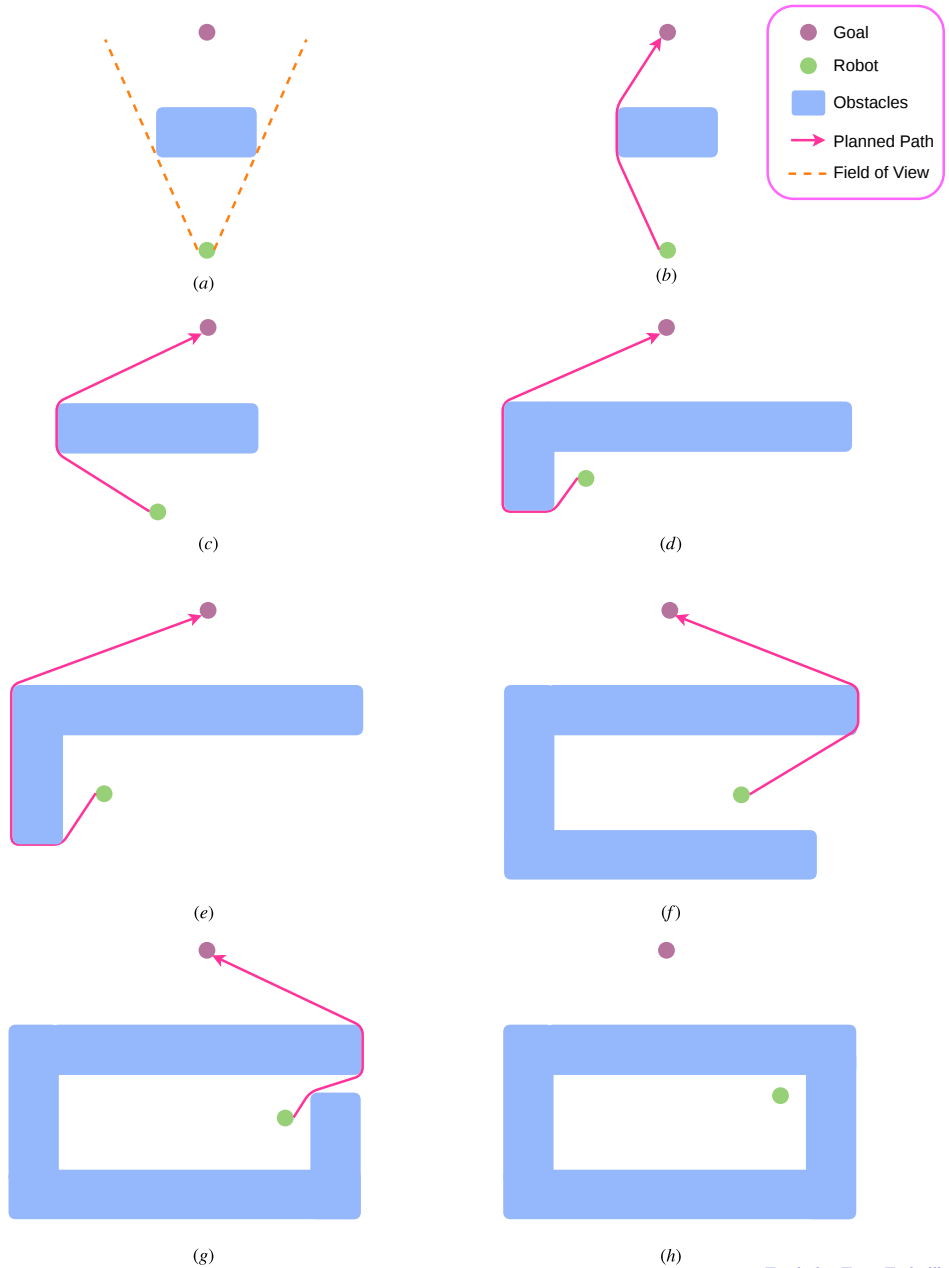
Path Planning Module



Need to Replan Path Module

1. Acquire point cloud in current frame w.r.t the world coordinate system
2. Downsample and filter the point cloud (voxel grid, IQR filter, statistical outlier removal filter)
3. Project the point cloud onto a plane to get local occupancy map
4. Check if there is any waypoint in the planned path collides with the local occupancy map
5. If there is collision, replan path

Find the Closed Boundary



Get Innermost Contour

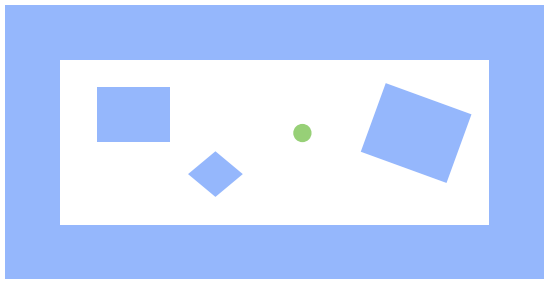


Figure: Occupancy Map

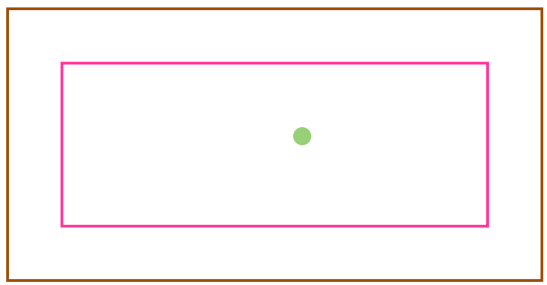


Figure: Contours that Contains the Green Point

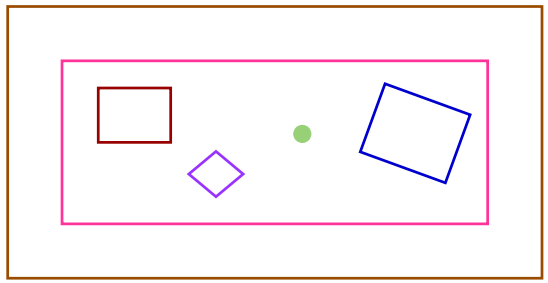


Figure: Contours of Occupancy Map

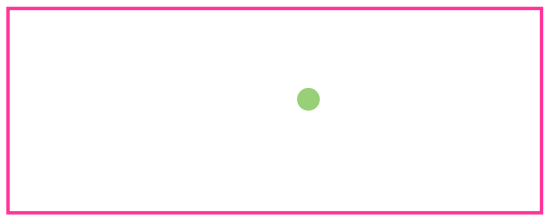
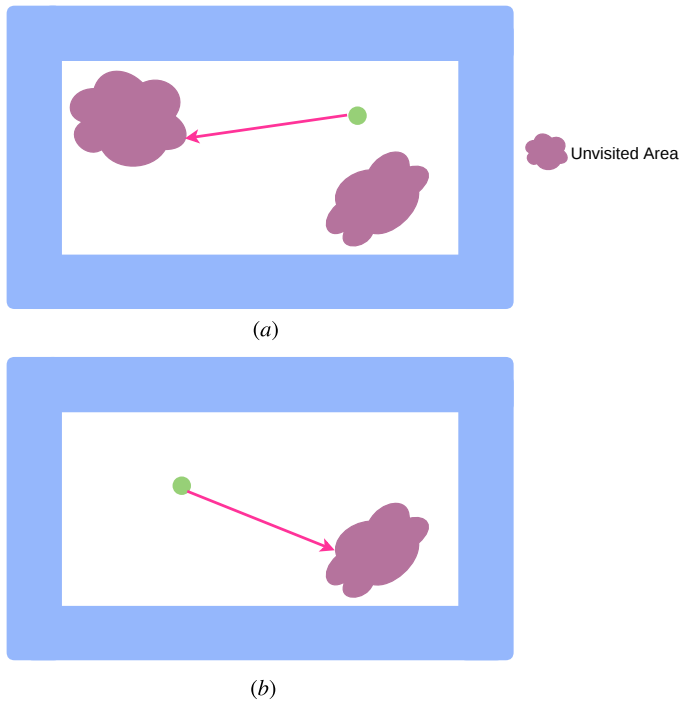


Figure: Closest Contour that Contains the Green Point

- Green Point can be the robot's starting position or current position

Clear Unvisted Area

- Project dense map onto a plane A (filter out ceiling and ground)
- Find the Inner-Most contour X in A
- Project dense map onto a plane B (filter out ceiling)
- Find the connected components in B inside the inner-most contour found in A
- Loop over all connected components whose areas are greater than a specified threshold value
  - Randomly pick a point in the connected component
  - Control the robot to go to that point



Contours in Pratice 1

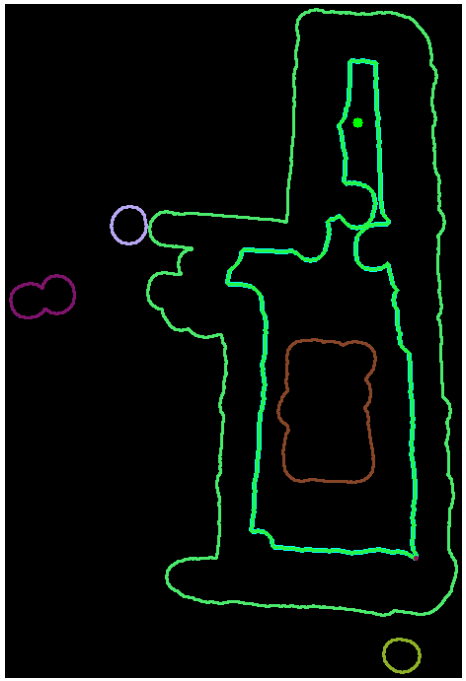


Figure: All contours found

Figure: Inner-most contour

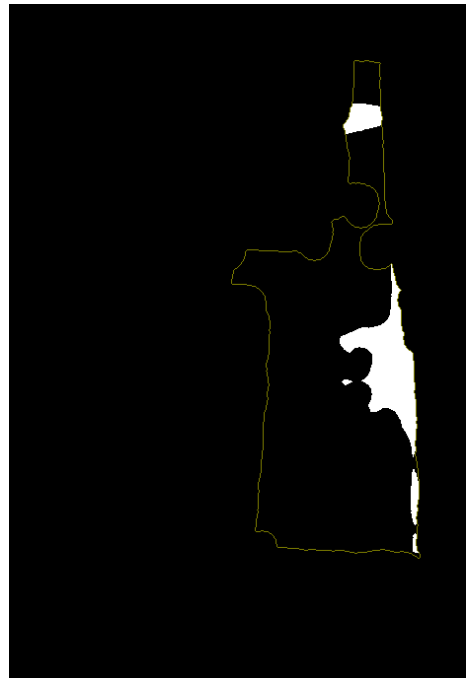


Figure: Unvisited Area

- Control robot to go to a position inside the unvisited area

Contours in Pratice 2

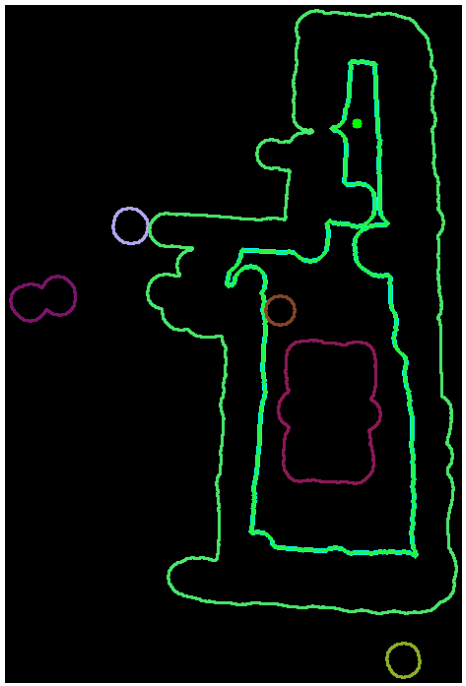


Figure: All contours found

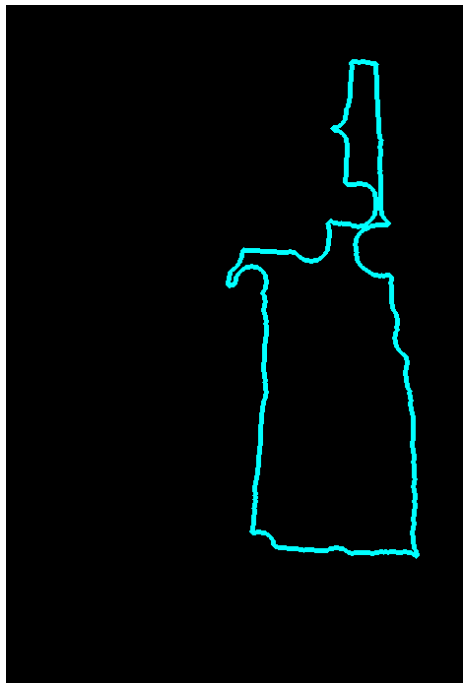


Figure: Inner-most contour

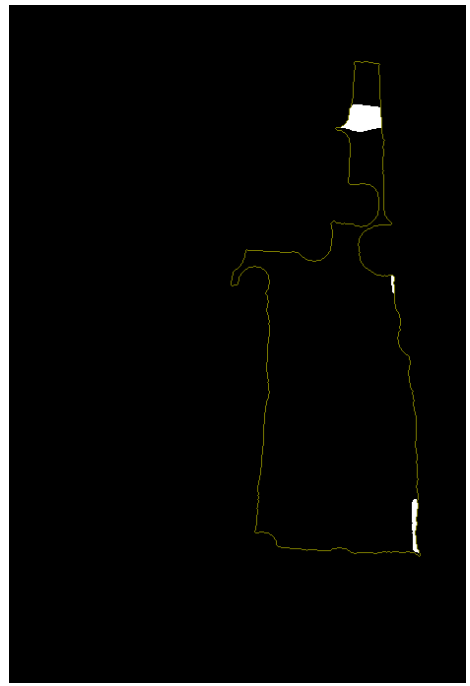
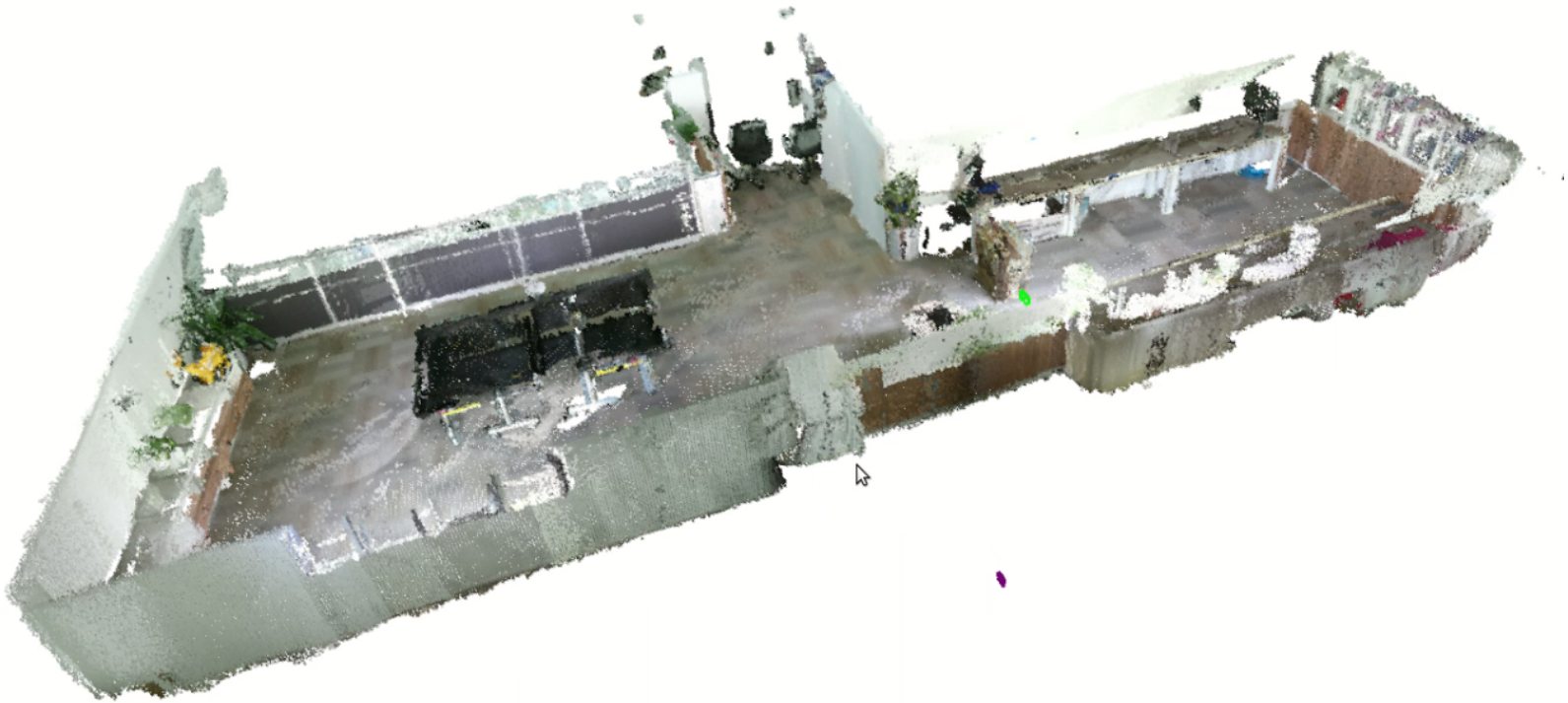


Figure: Unvisited Area

- Unvisited area gets smaller

Dense Map Built by Automatic Map Building



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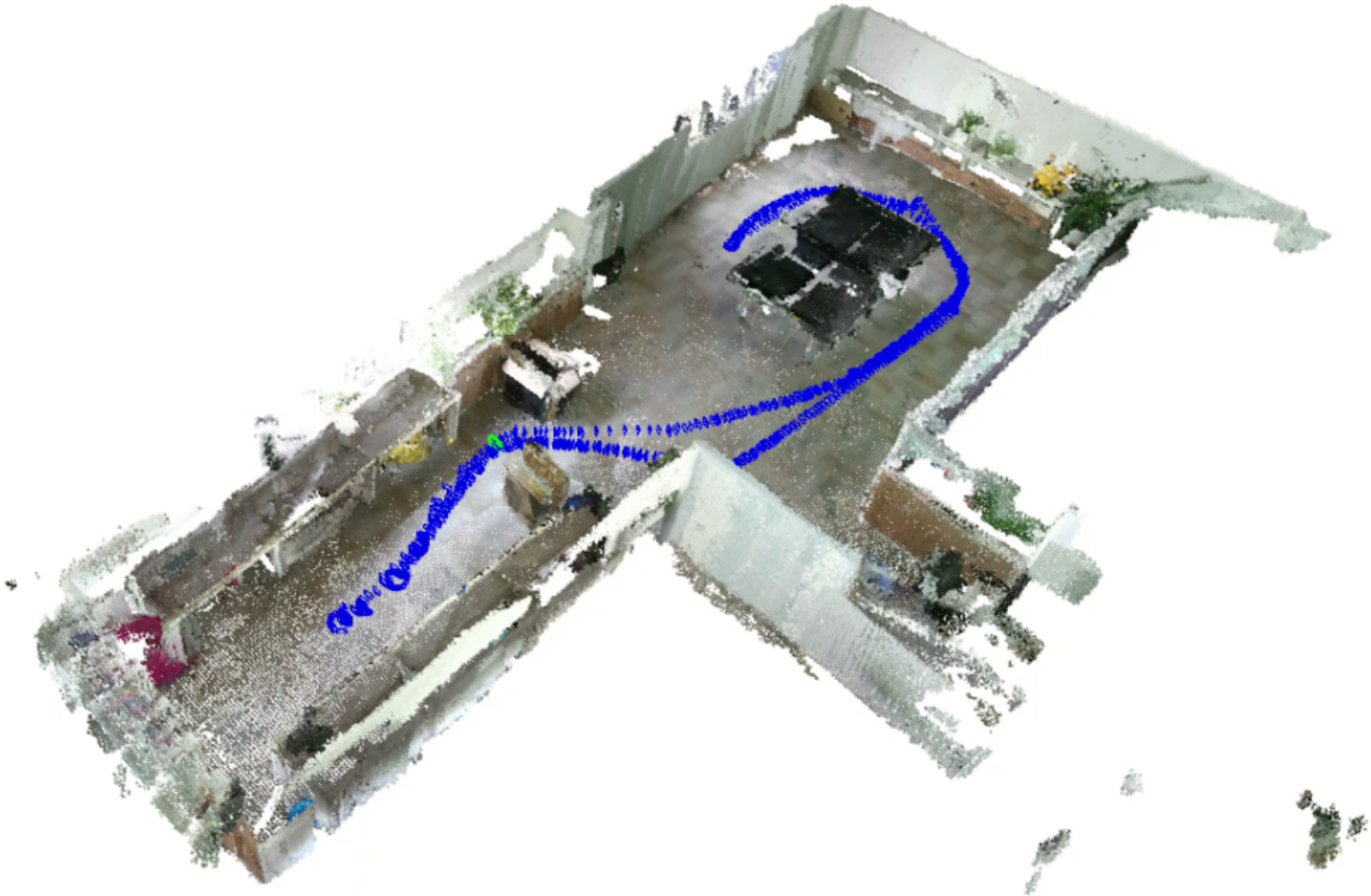
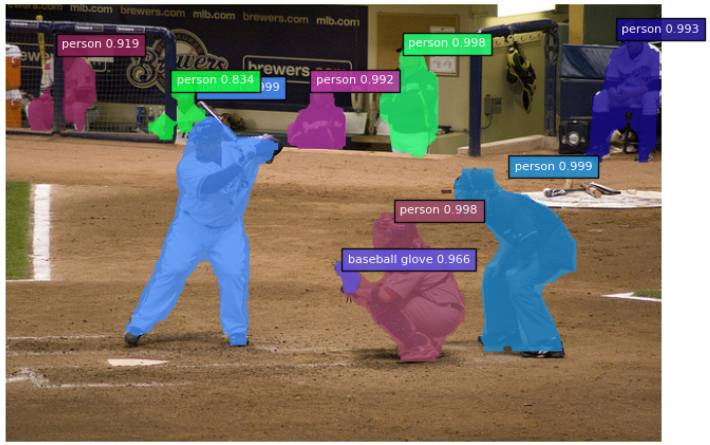


Outline

Object Recognition and Segmentation

- Built upon FCIS (Fully Convolutional Instance-aware Semantic Segmentation)
- SLAM sends color image and depth image to FCIS via socket
- FCIS performs object recognition and segmentation
- Calculate the center (from mean value or median value) of the segmented objects, send them back to SLAM
- SLAM can then control the robot to approach the object given user-specified object's name

FCIS Demo



- Segmentation and object recognition on color images