Semantic Map Augmentation for Robot Navigation: A Learning Approach based on Visual and Depth Data

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Symposium

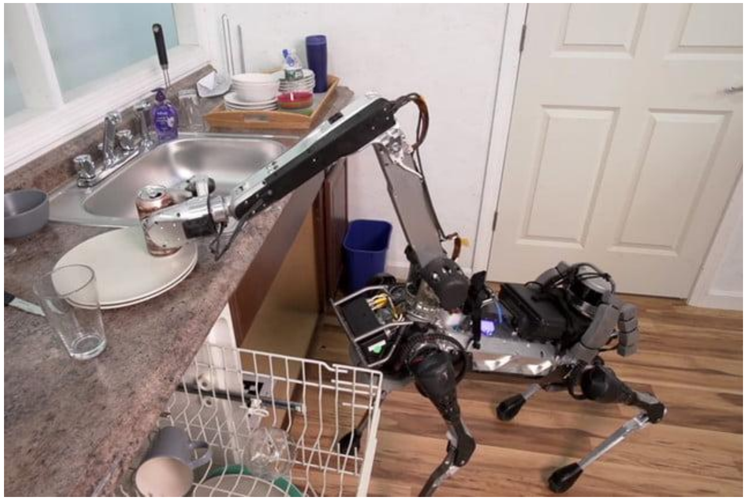
Introduction

Introduction - Motivation

“For the next level of robot intelligence and intuitive user interaction, maps need to extend beyond geometry and appearance — they need to contain semantics.”

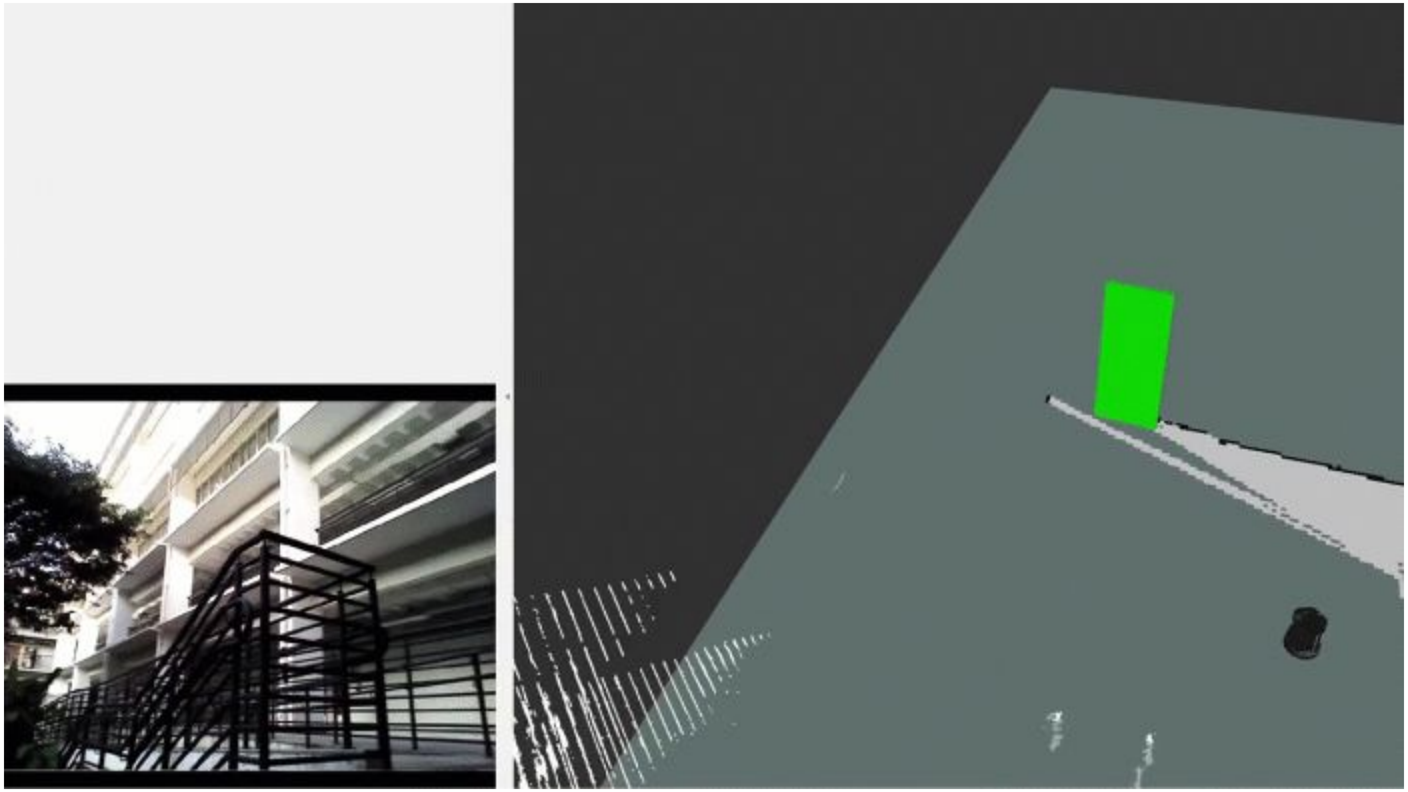
Source: *SemanticFusion: Dense 3D Semantic Mapping with Convolutional Neural Networks - ICRA 2017*

Introduction - Motivation

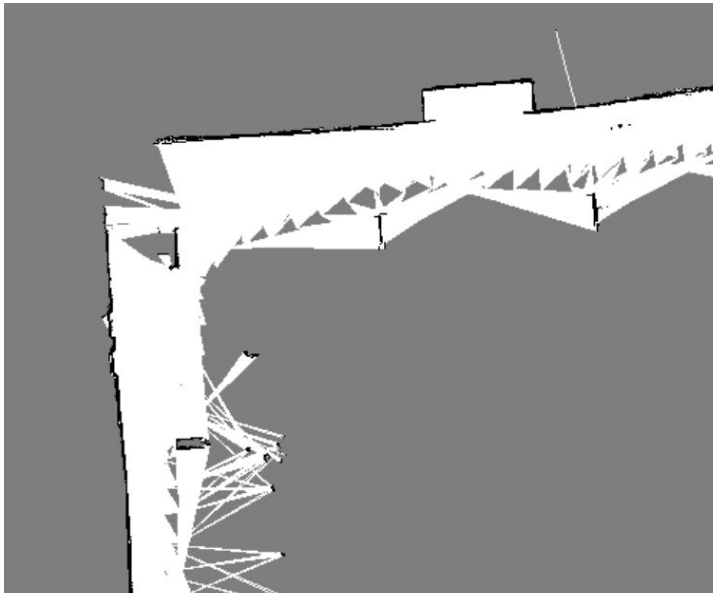


Introduction - Our Goal

- Build **augmented maps** with semantic information

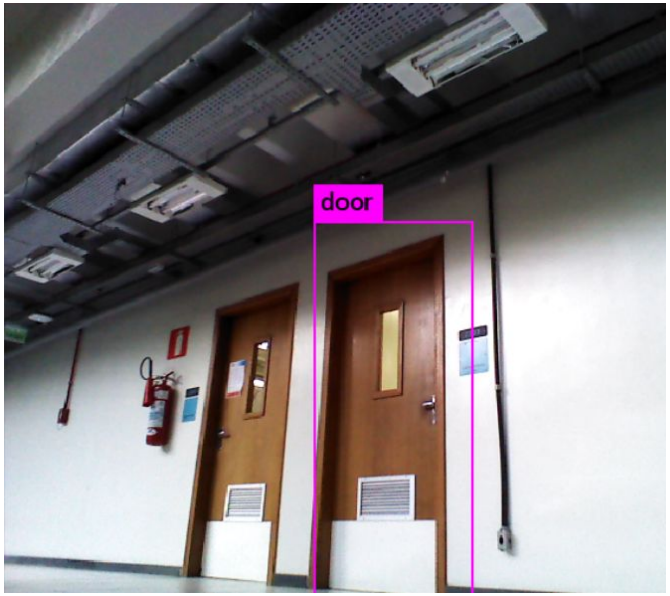


Introduction



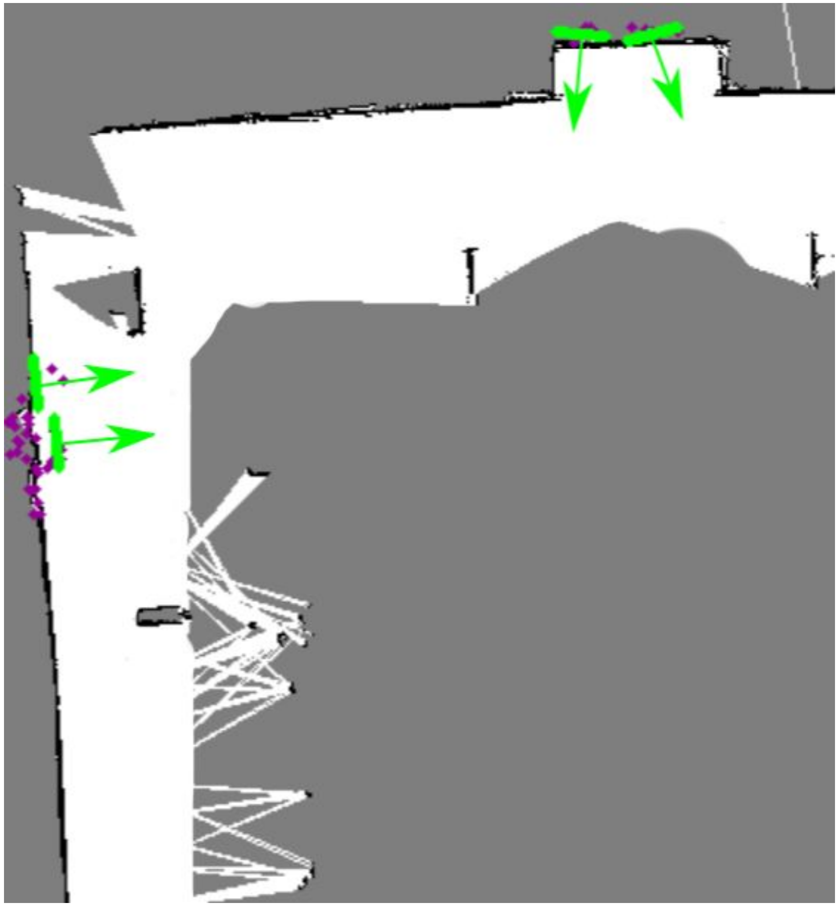
Metric Map (SLAM)

+



Object Detection

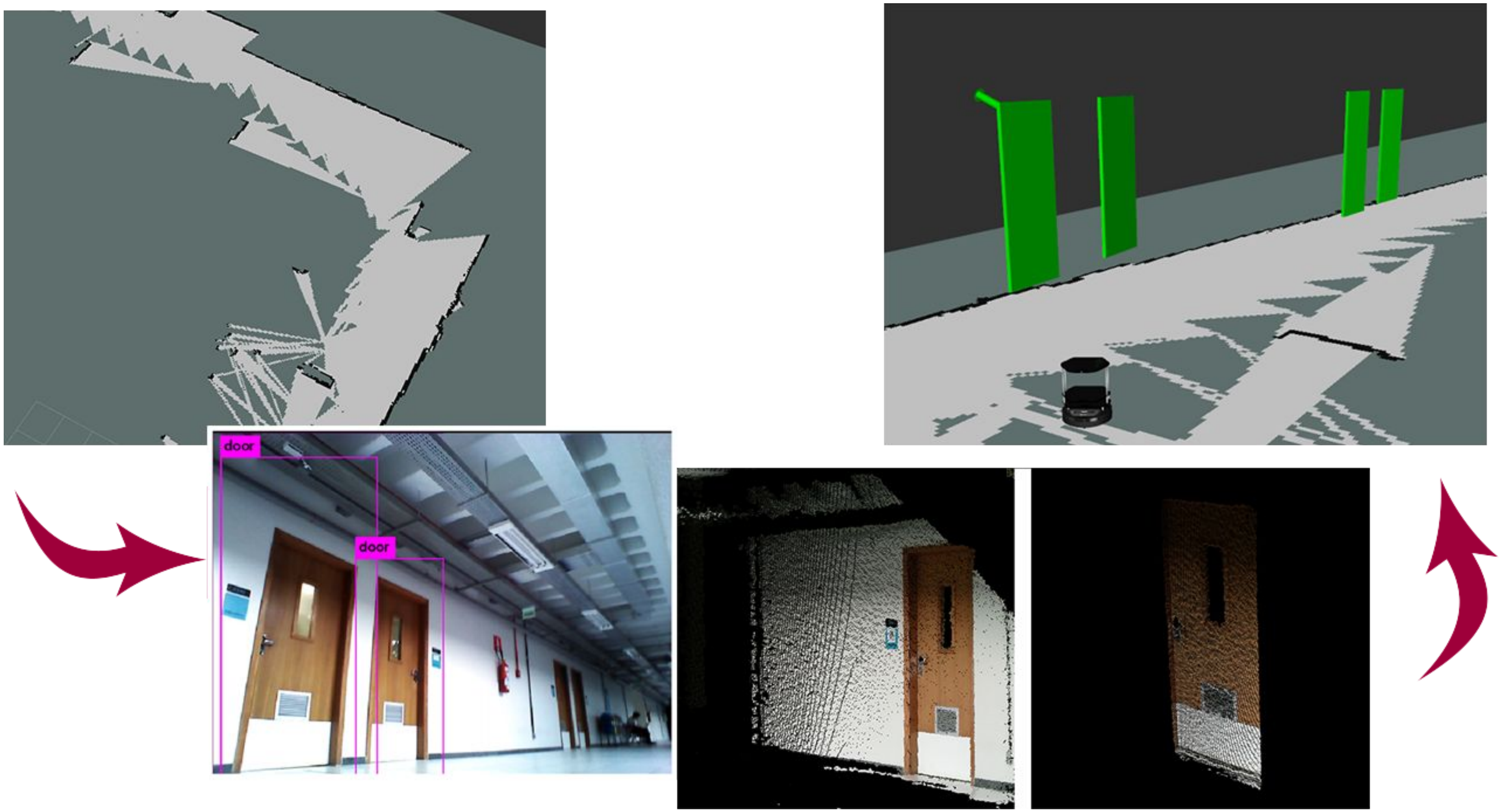
Introduction



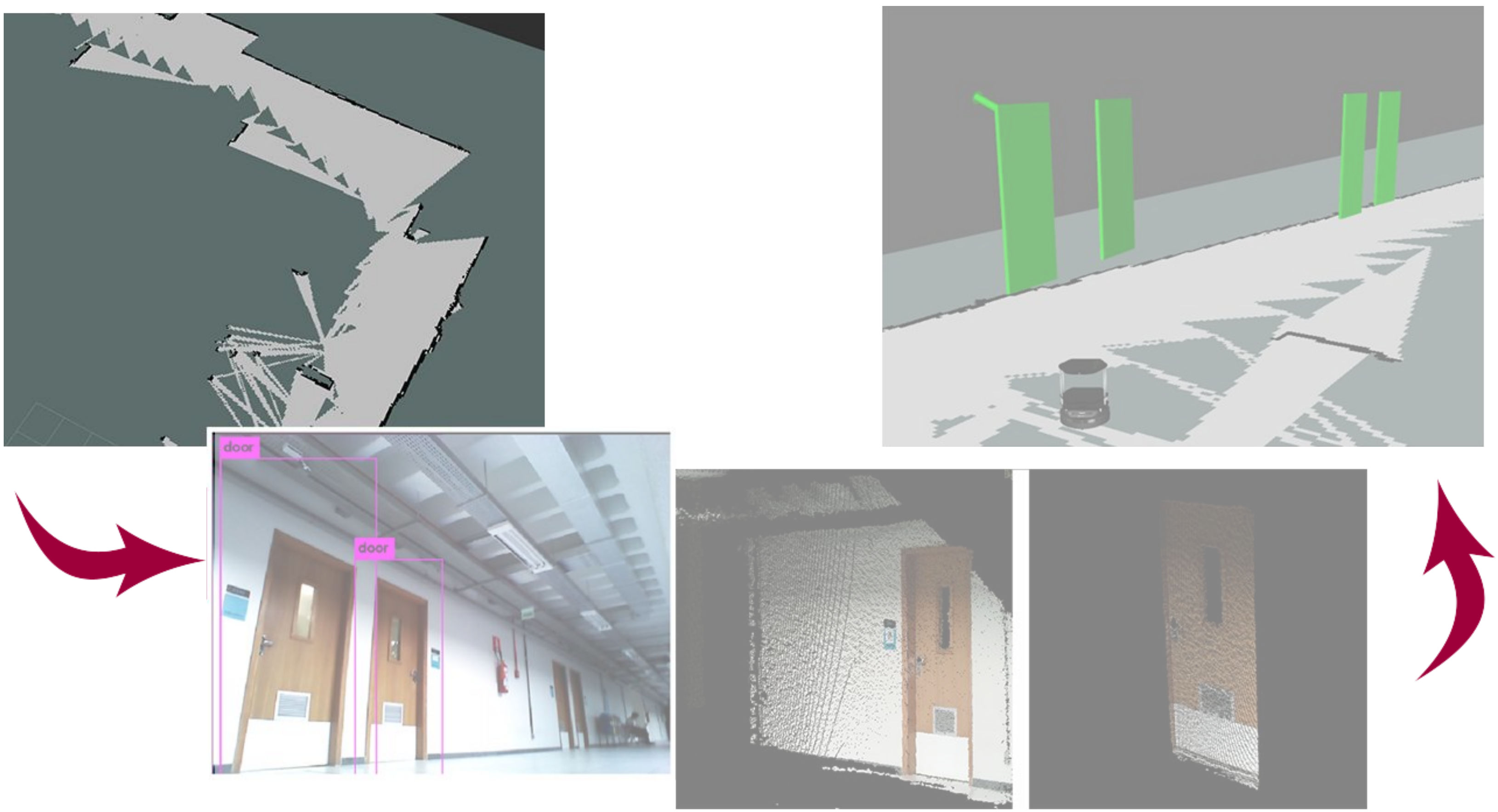
Augmented map with semantic classes

Methodology

Pipeline Overview



Pipeline Overview



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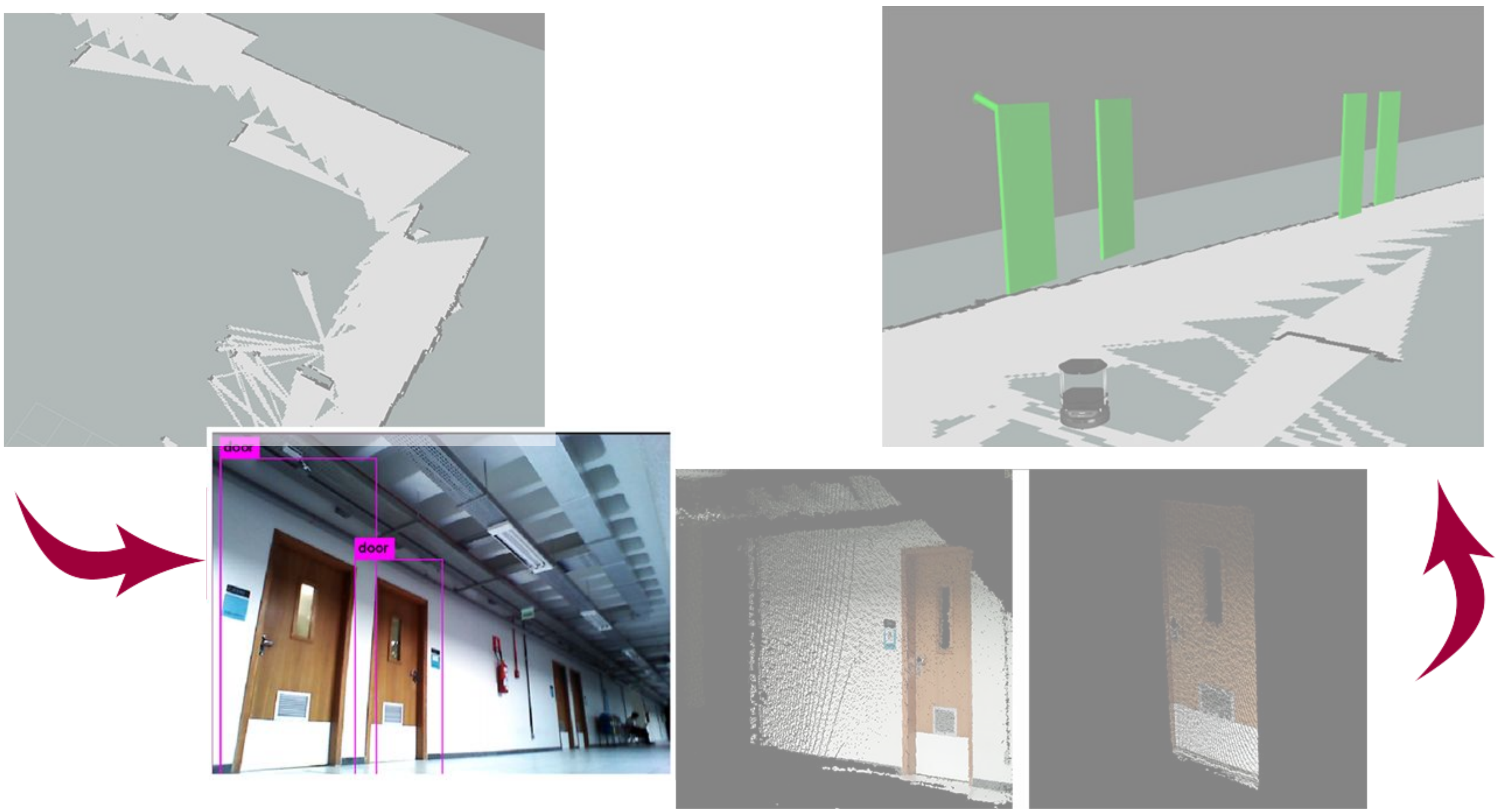
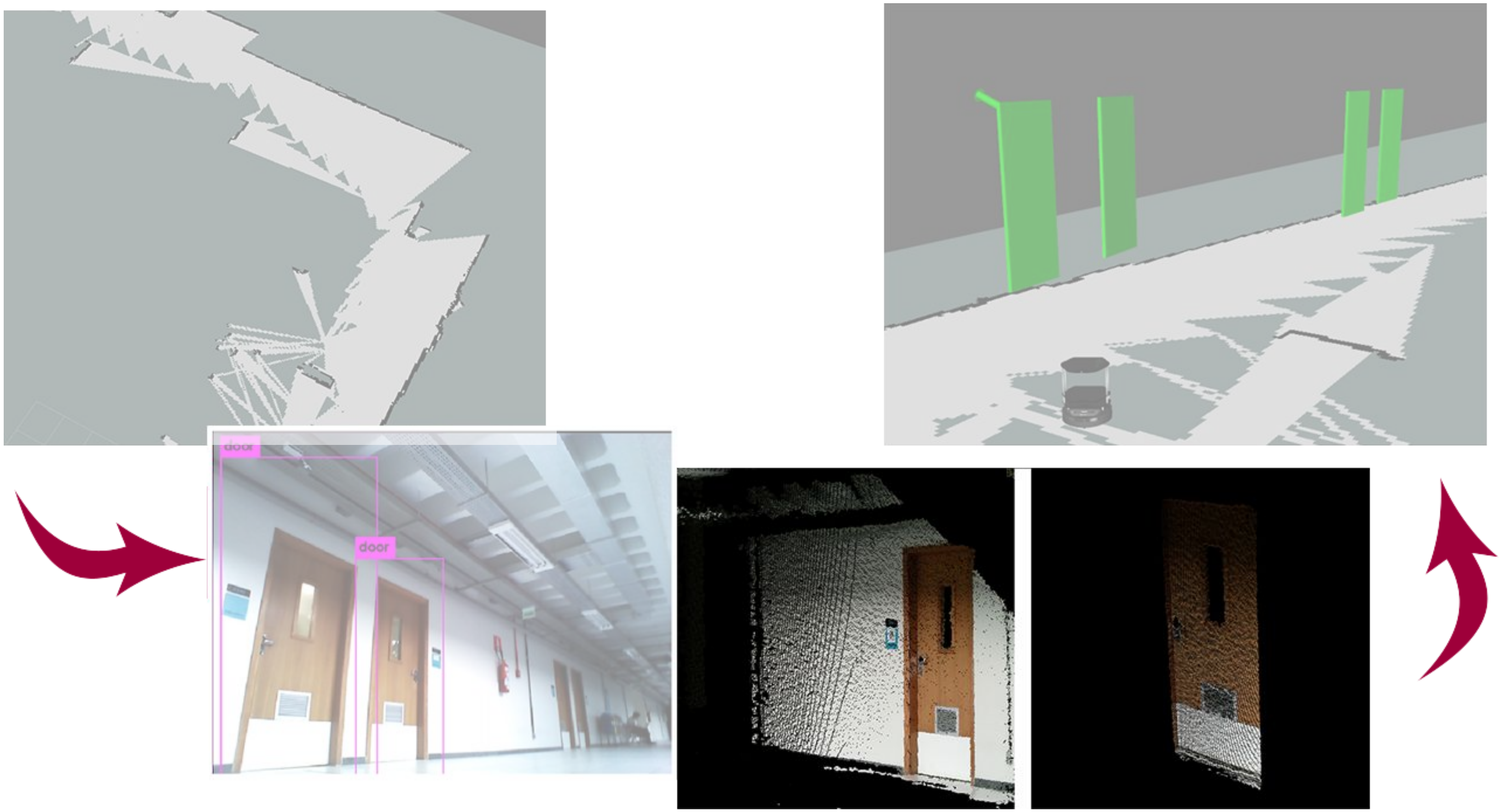
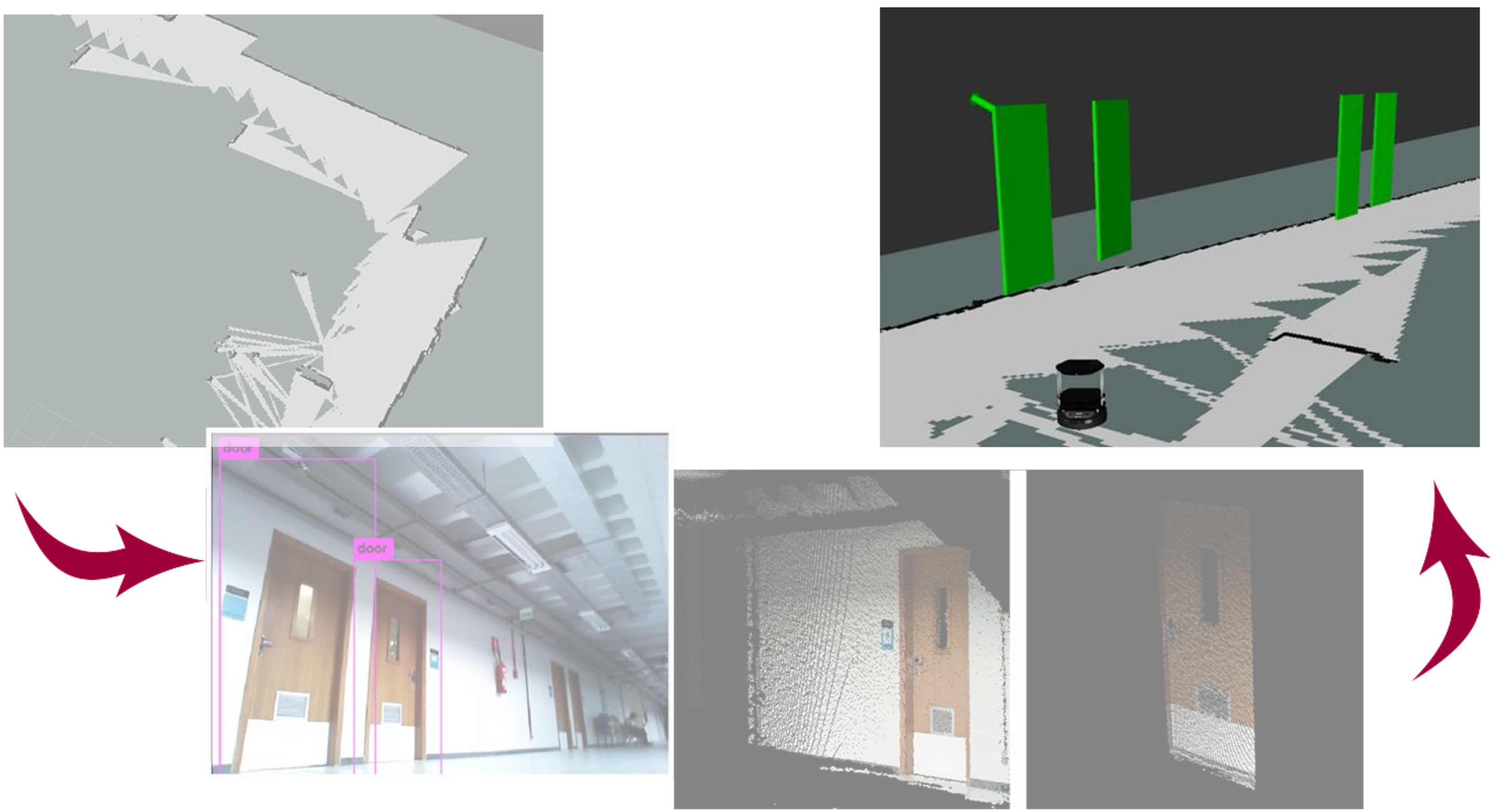


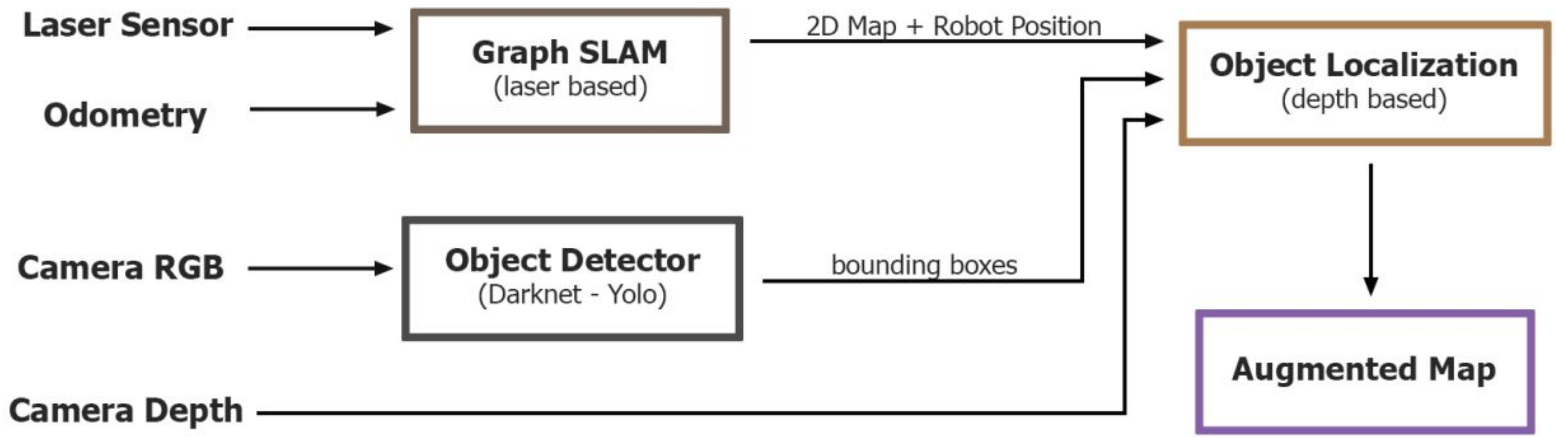
Pipeline Overview



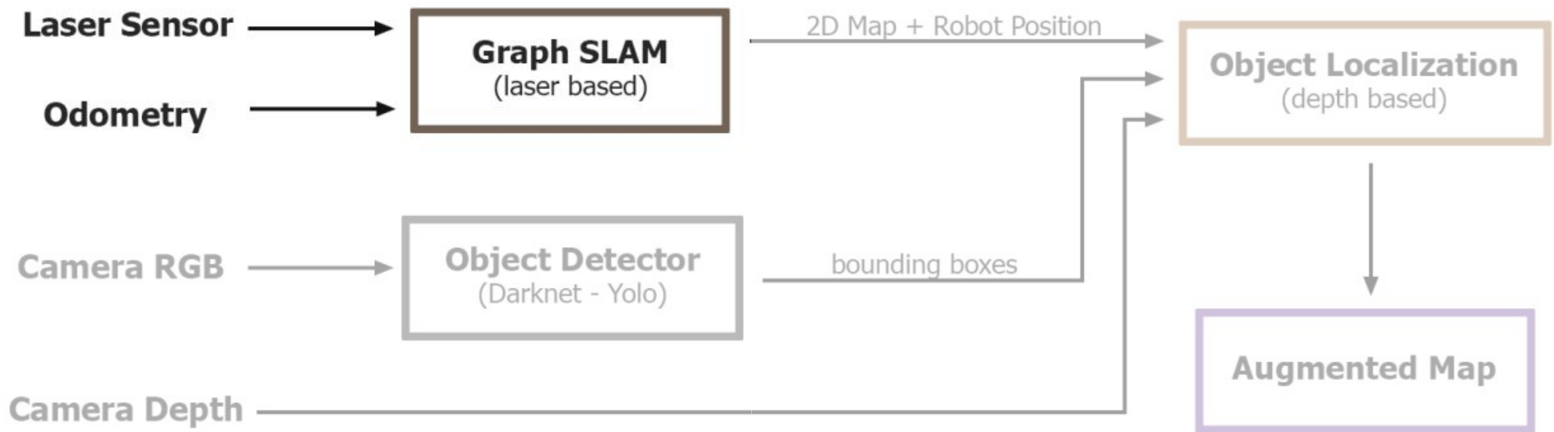
Pipeline Overview



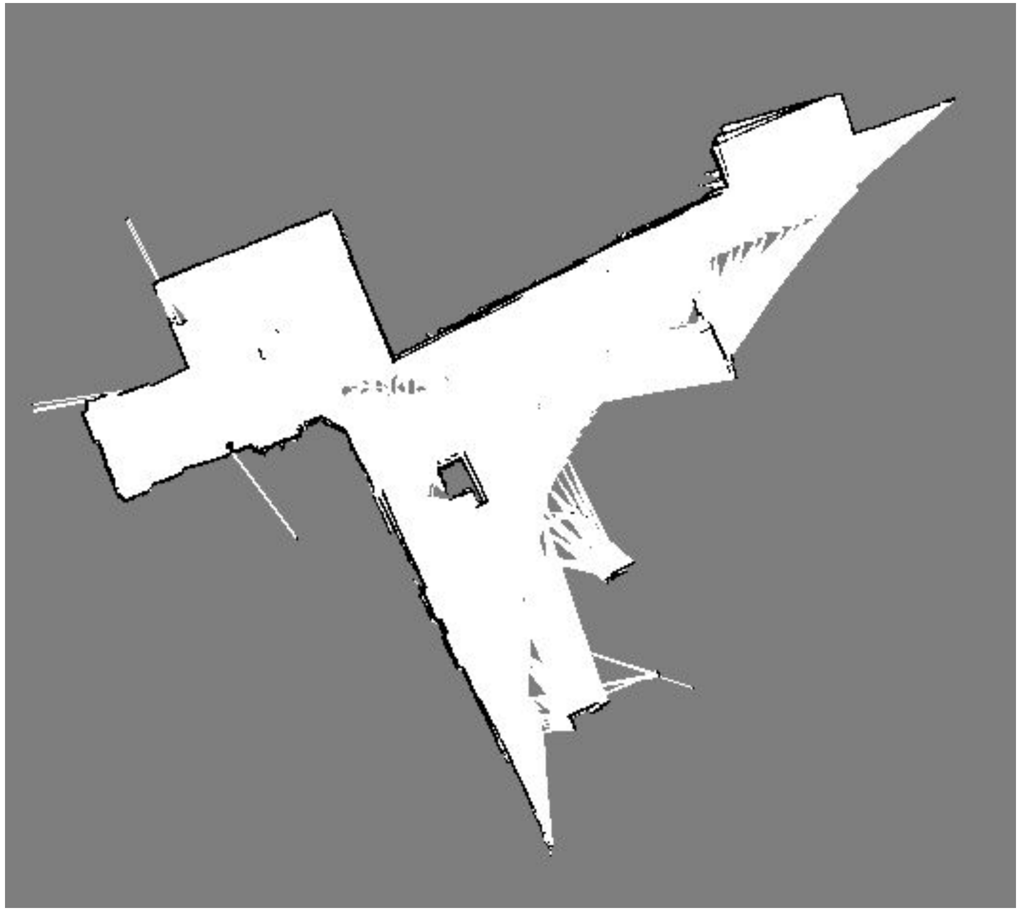
Pipeline


Laser Sensor
Odometry
Graph SLAM
(laser based)
2D Map + Robot Position
Object Localization
(depth based)
Camera RGB
Object Detector
(Darknet - Yolo)
bounding boxes
Augmented Map
Camera Depth

Pipeline - Metric Map (SLAM)

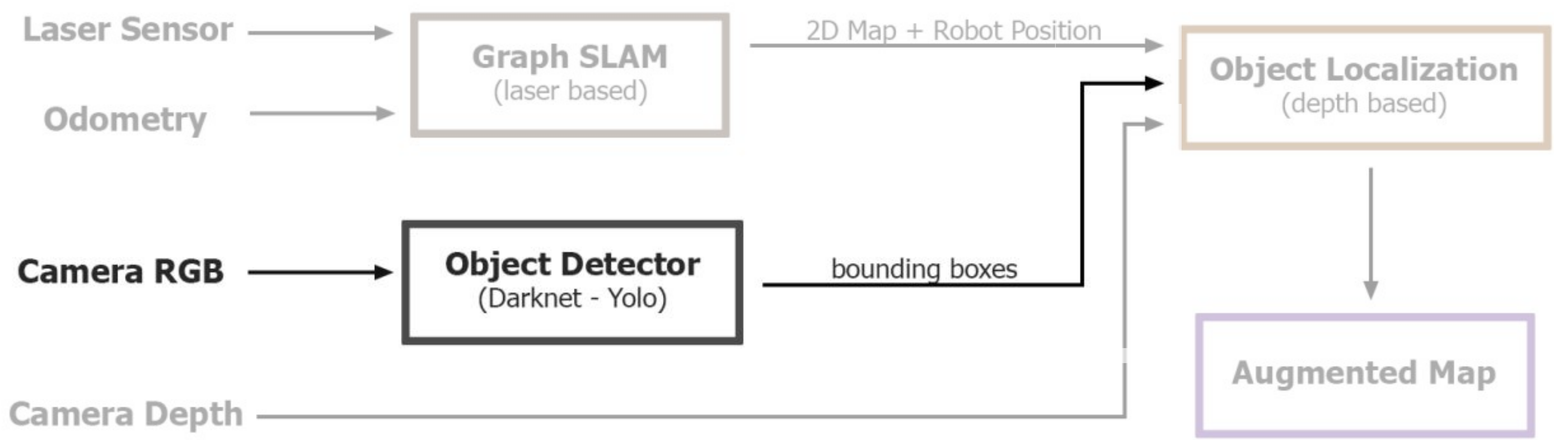


Pipeline - Metric Map (SLAM)

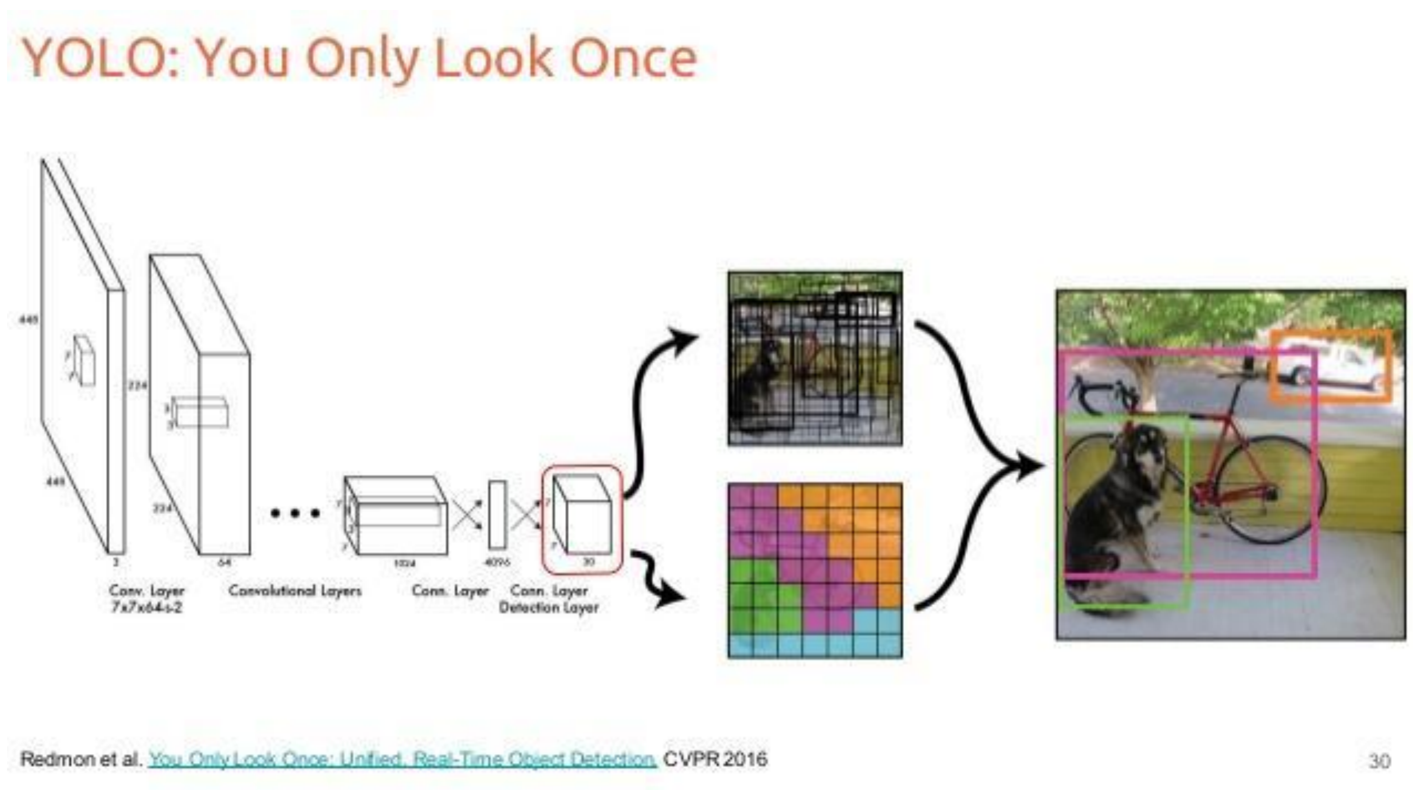


*Grisettiyz, Giorgio, Cyrill Stachniss, and Wolfram Burgard. "Improving **grid-based slam** with rao-blackwellized particle filters by adaptive proposals and selective resampling." Proceedings of the 2005 IEEE international conference on robotics and automation. IEEE, 2005.*

Pipeline: Object Detection

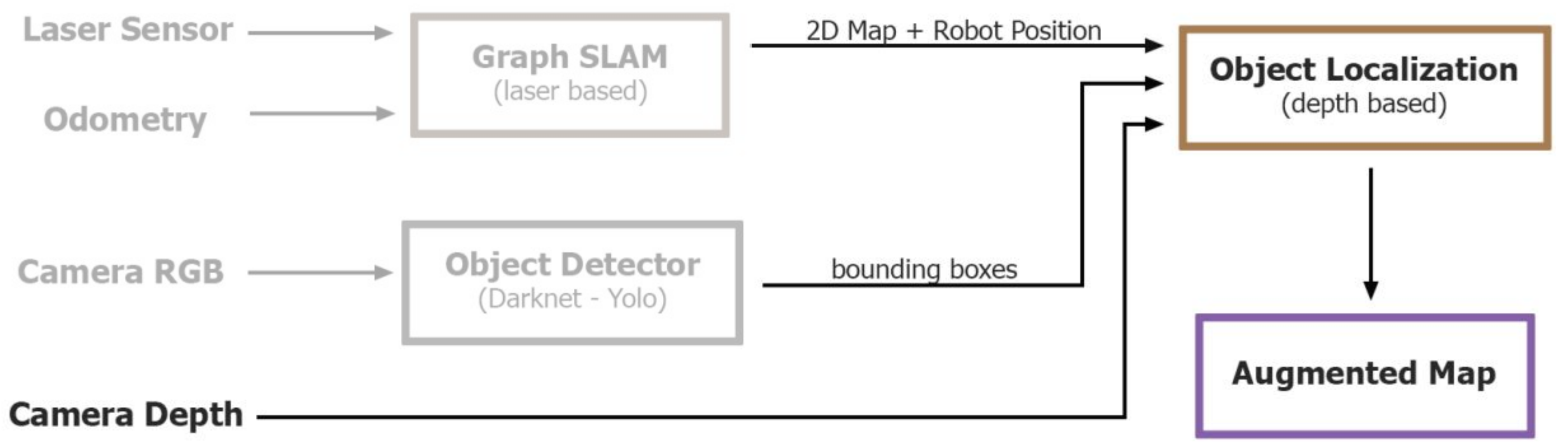


Pipeline: Object Detection



Redmon, Joseph, and Ali Farhadi. "YOLO9000: better, faster, stronger." arXiv preprint (2017).

Pipeline: Object Localization



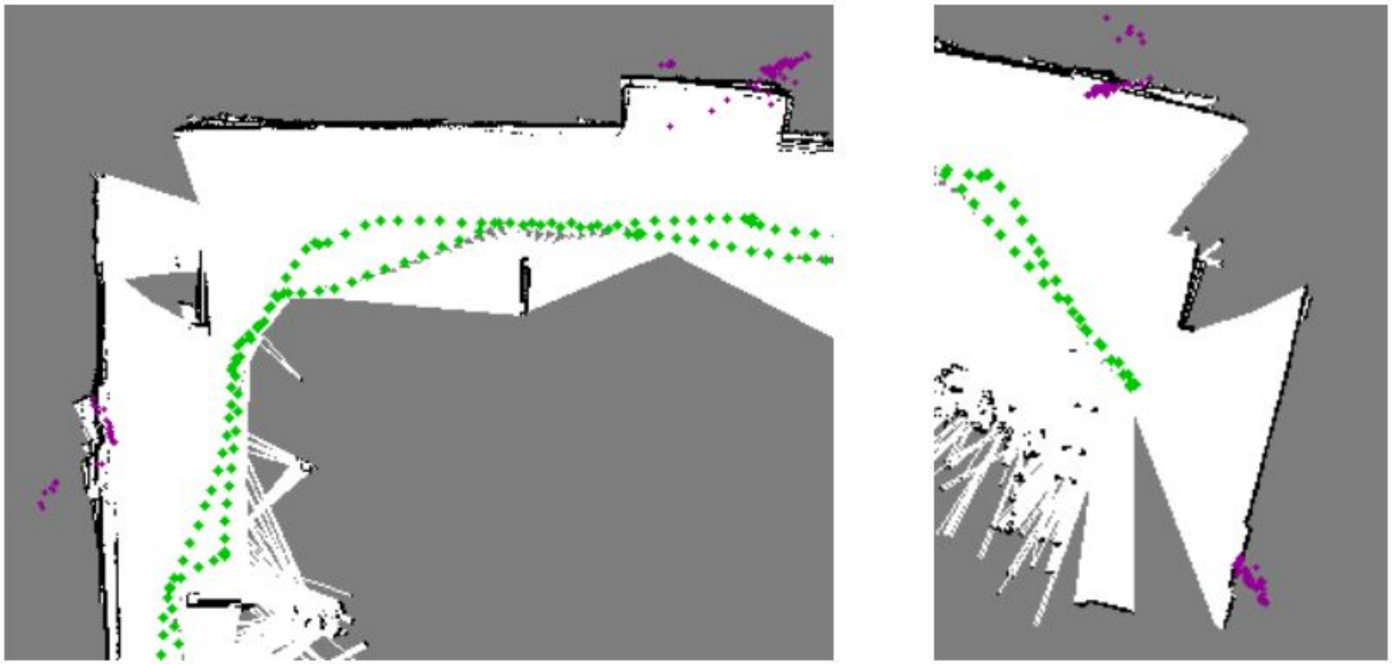
Object Localization

Point cloud representation of input camera has one-to-one correspondence with RGB image pixels.

Pipeline: Object Localization

The object localization is done using the point cloud of the detected class.

Pipeline: Object Tracking



Purple dots represent observations of the same class. Multiple observations of the same class might indicate a single instance (i.e. the object) or multiple instances of that class.

Pipeline: Object Tracking

- Each new instance of an object is modeled with a different Kalman filter object

- We start modelling "door" objects:
  - Doors are important for navigation and scene representation.
  - Simple geometric model (plane patch) and tracking:

$$\begin{cases} \mathbf{x}_i[k] = \mathbf{x}_i[k-1] + \tilde{\mathbf{w}}[k] \text{ and } \tilde{\mathbf{w}} \sim \mathcal{N}\left(\mathbf{0}_{3\times1}, \mathbf{W}\right) \\ \mathbf{y}[k] = \mathbf{x}_i[k] + \tilde{\mathbf{z}}[k] \text{ and } \tilde{\mathbf{z}} \sim \mathcal{N}\left(\mathbf{0}_{3\times1}, \mathbf{Z}\right) \end{cases}$$

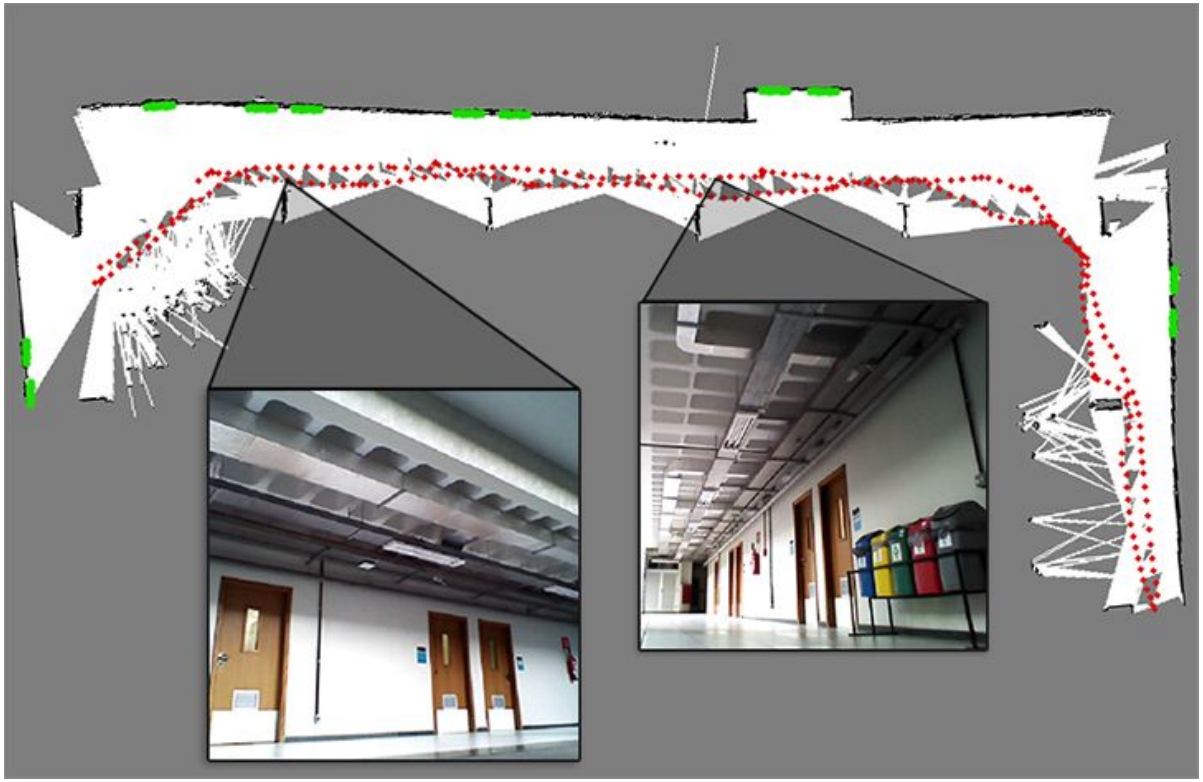
Experiments and Results

Online Experiments: Test Platform

Kobuki Base, RGBD camera, 2D Lidar.

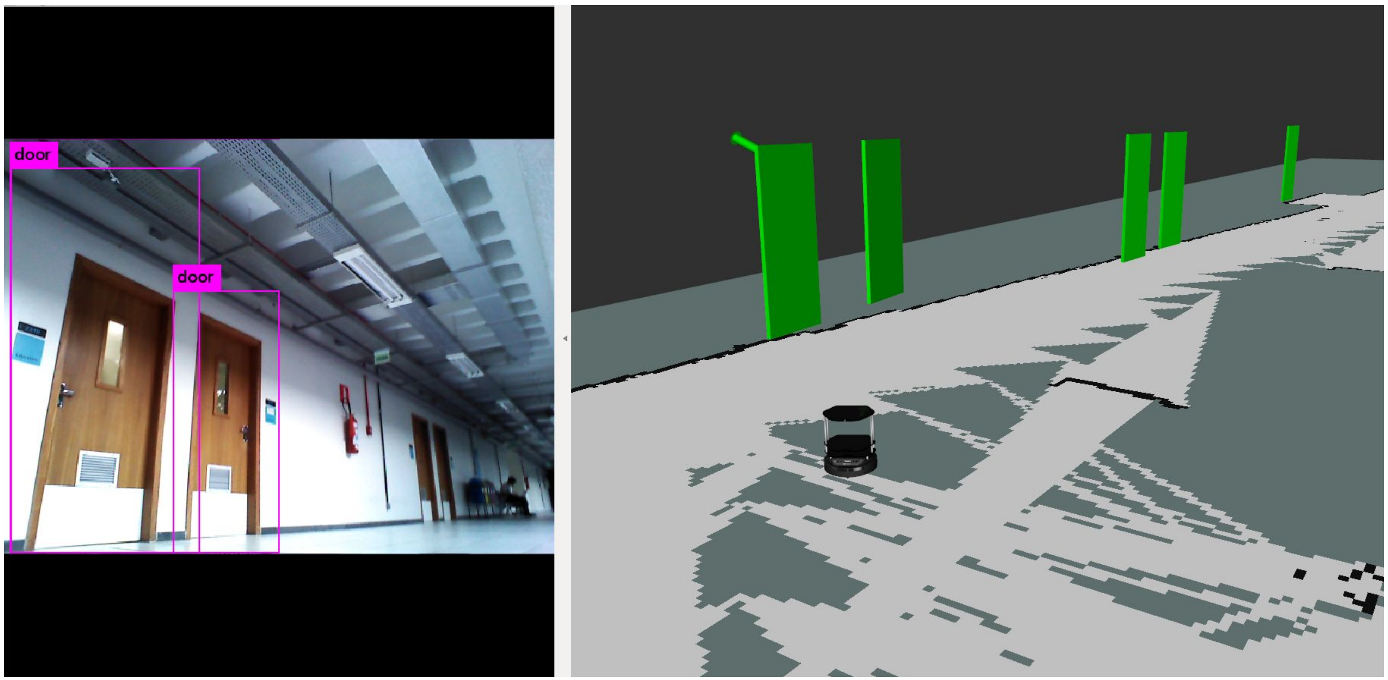
Online Datasets

- Recorded datasets: rosbag of several sequences
- Available for download at :
  https://www.verlab.dcc.ufmg.br/semantic-mapping-for-robotics/



Results

1. Augmented map with semantic classes
2. 3D rendering of robot view



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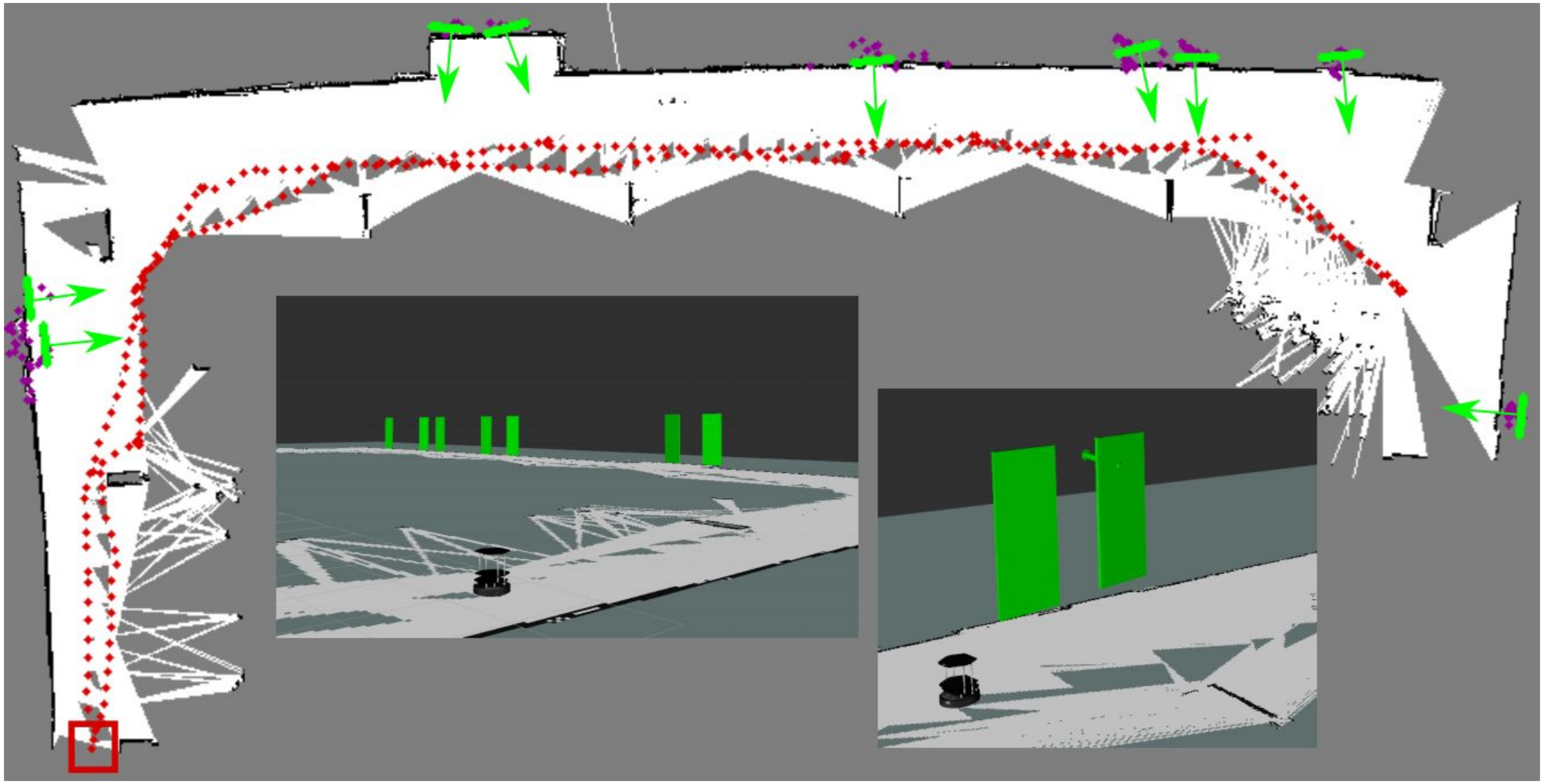
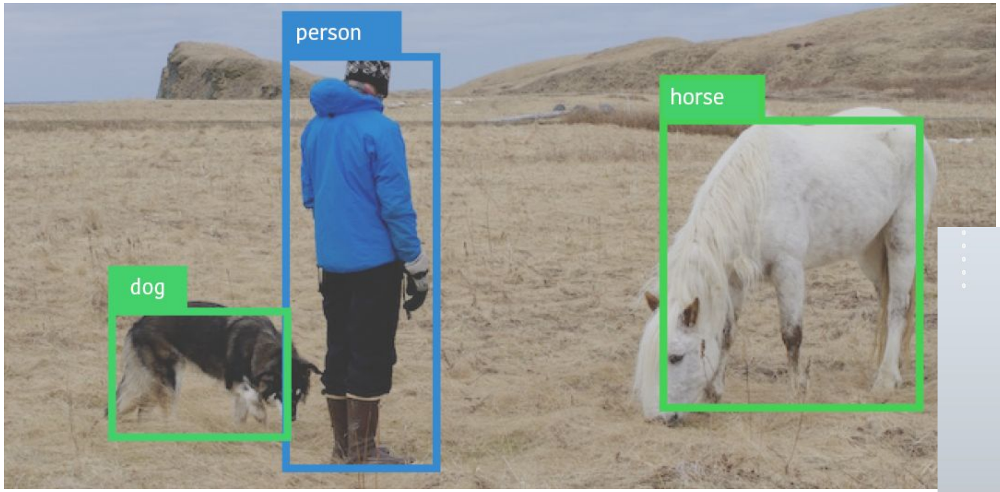
Results

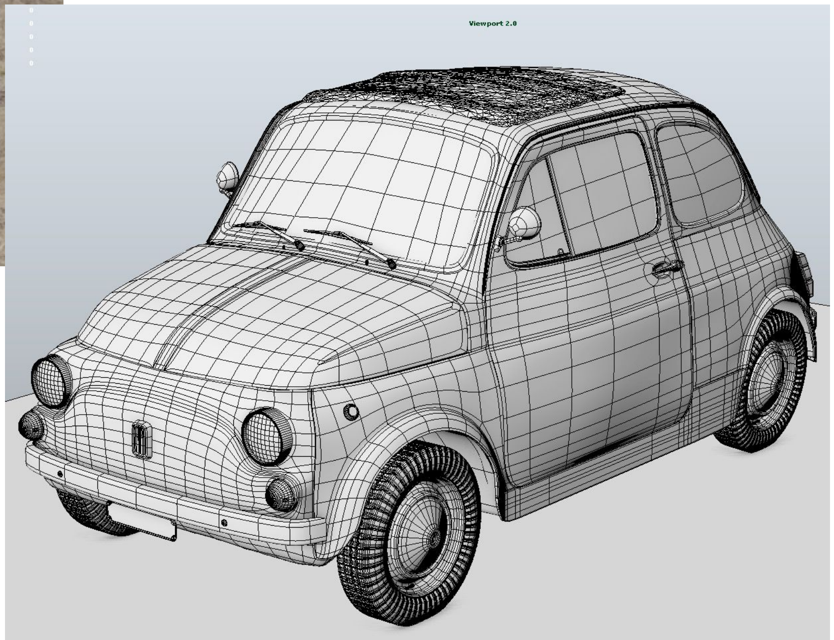
Top-view of constructed map. Doors are represented in green



Future Work

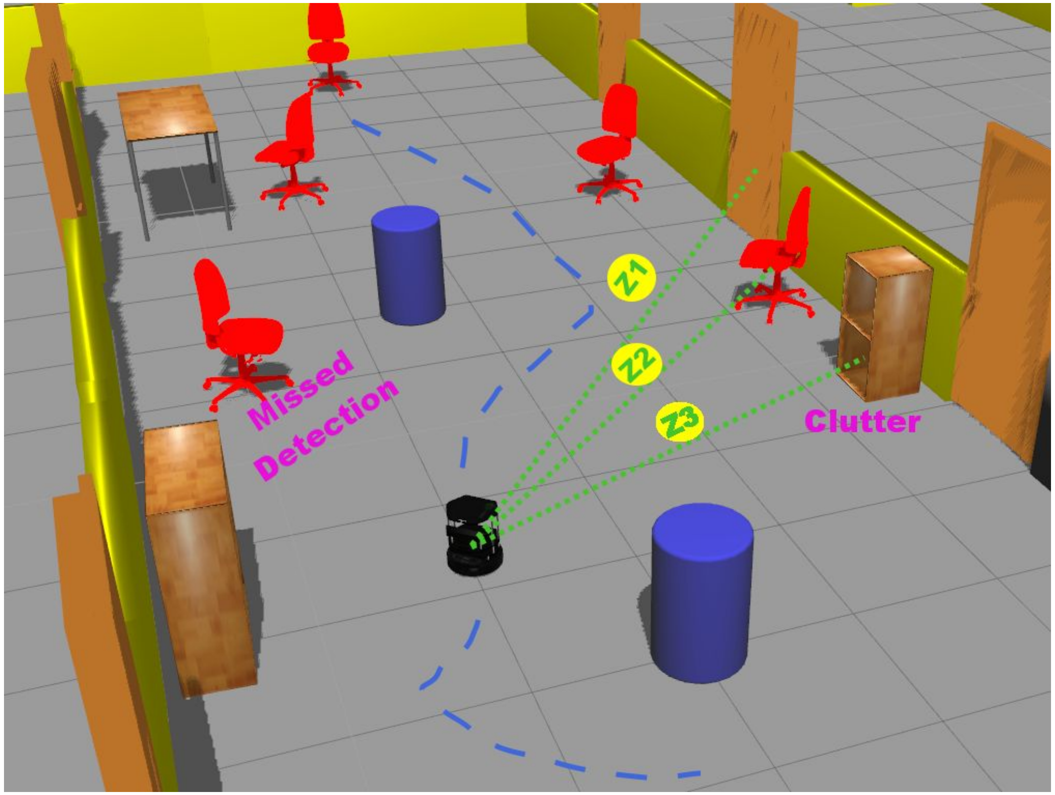
Future Work





Add classes and their 3D model

Future Work



Semantic SLAM

Project page and source code can be found at:
https://www.verlab.dcc.ufmg.br/semantic-mapping-for-robotics/

Thank you!
Questions?

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