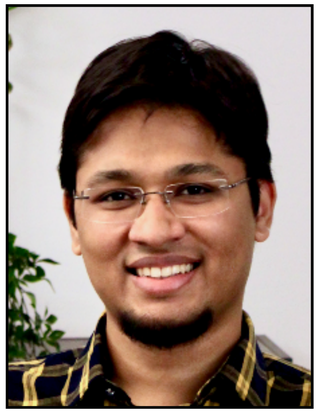
Carnegie Mellon University

facebook Artificial Intelligence Research

Object Goal Navigation using Goal-oriented Semantic Exploration

Winner CVPR 2020 Habitat ObjectNav Challenge

Team Arnold (SemExp)



Devendra Singh Chaplot

Dhiraj Gandhi

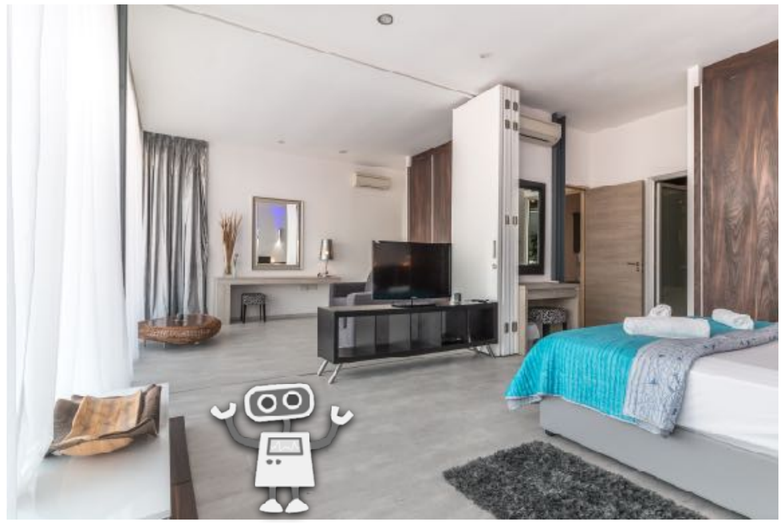
Abhinav Gupta

Ruslan Salakhutdinov

Webpage: https://devendrachaplot.github.io/projects/semantic-exploration

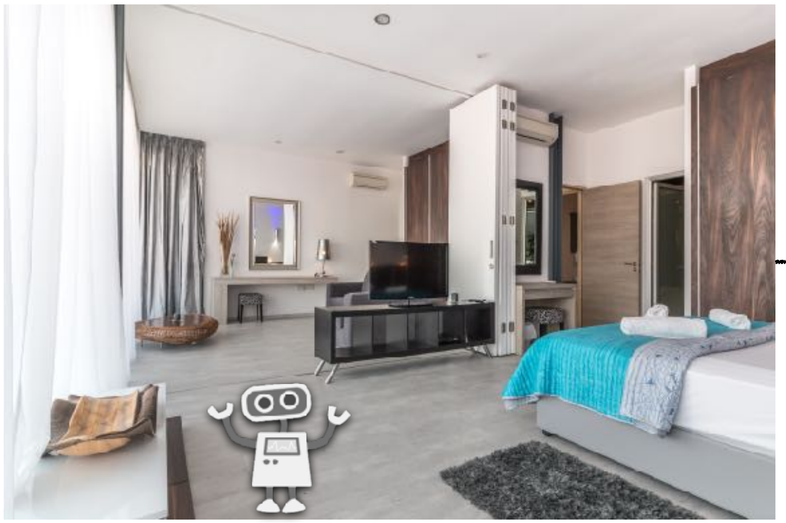
Object Goal Navigation

Object Goal Navigation



Object Goal: dining table

Object Goal Navigation



Object Goal: dining table

Passive

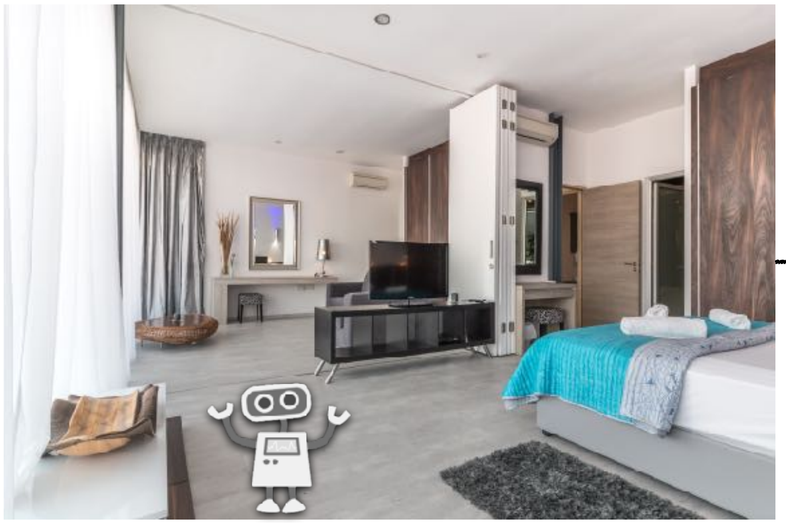
Geometric Scene Understanding

Understanding navigable space

Semantic Scene Understanding

Object detection and segmentation

Object Goal Navigation



Object Goal: dining table

Passive

Active

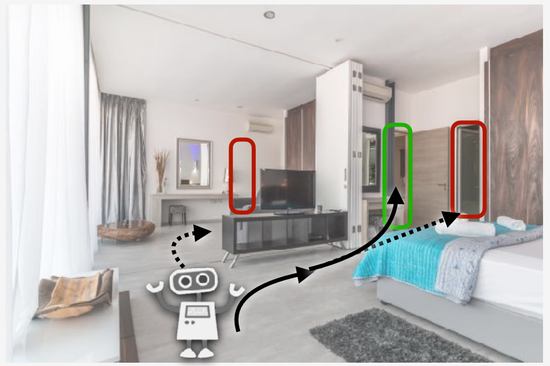
Geometric Scene Understanding

Understanding navigable space

Semantic Scene Understanding

Object detection and segmentation

Learning Semantic Priors

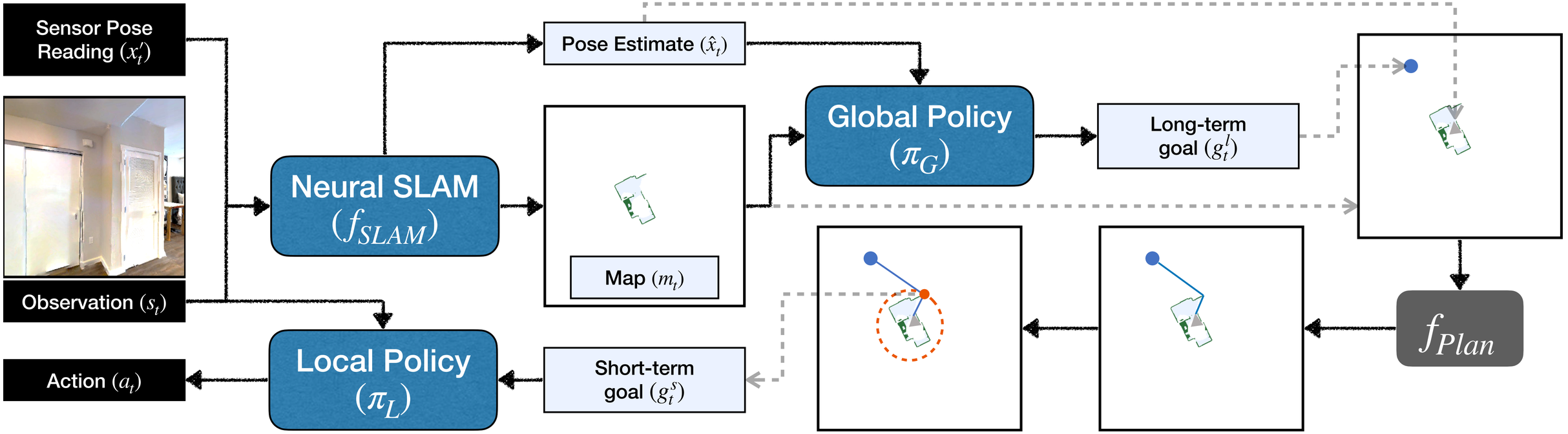


Where is ‘dining table’ more likely to be found?

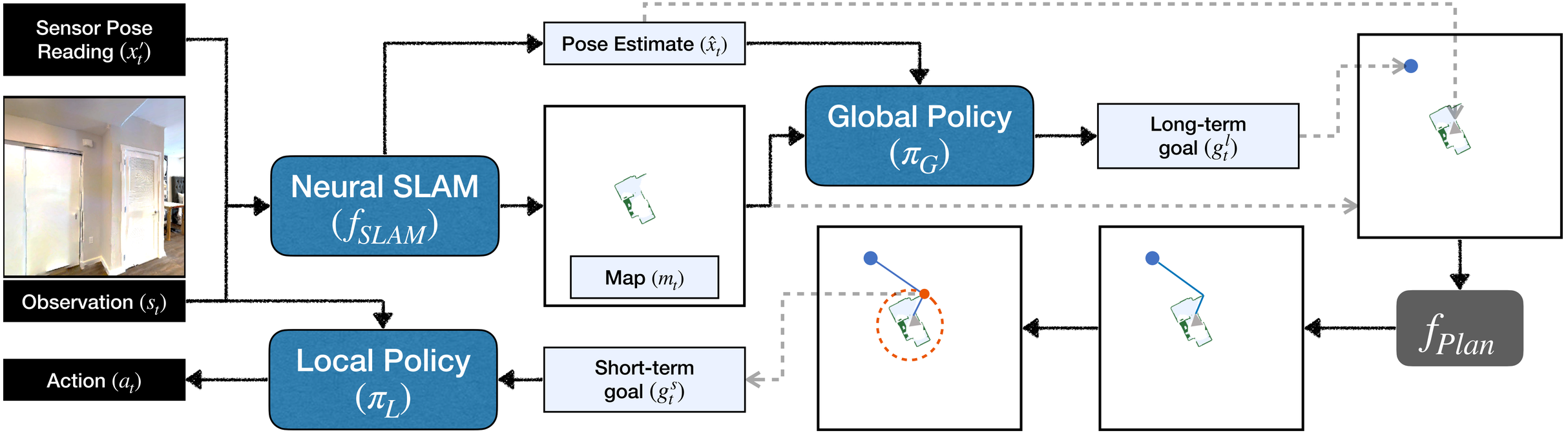
Episodic Memory

Keeping track of explored and unexplored areas

Active Neural SLAM



Active Neural SLAM



[*Chaplot el al. ICLR-20*]

Incorporating Semantics

Obstacle Map Representation
(Active Neural SLAM)

Obstacle Map $(2 \times M \times M)$

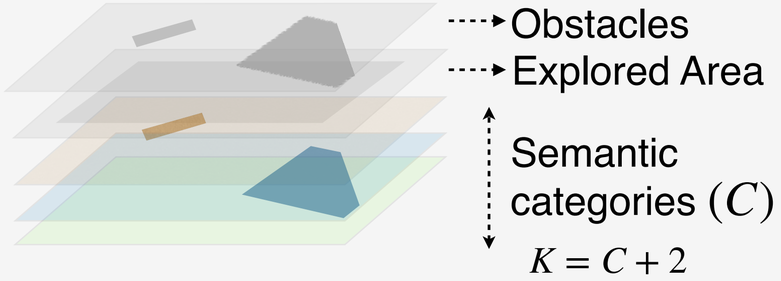
Incorporating Semantics

Obstacle Map Representation (Active Neural SLAM)

Obstacle Map $(2 \times M \times M)$

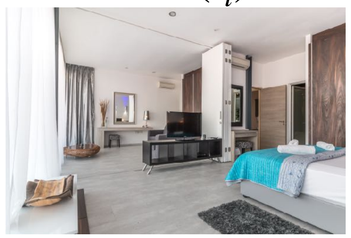
Semantic Map Representation (SemExp)

Semantic Map $(K \times M \times M)$



Semantic Mapping

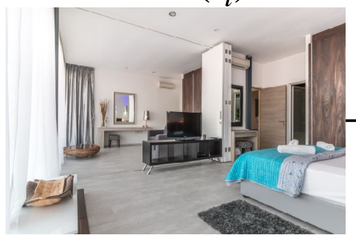
RGB (I_t)



Depth (D_t)

Semantic Mapping

RGB (I_t)



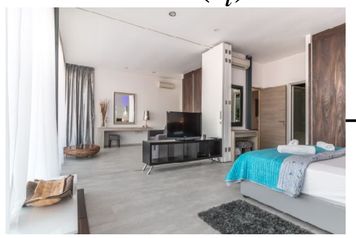
Depth (D_t)

Mask RCNN

First-person Semantic Predictions

Semantic Mapping

RGB (I_t)



Mask RCNN

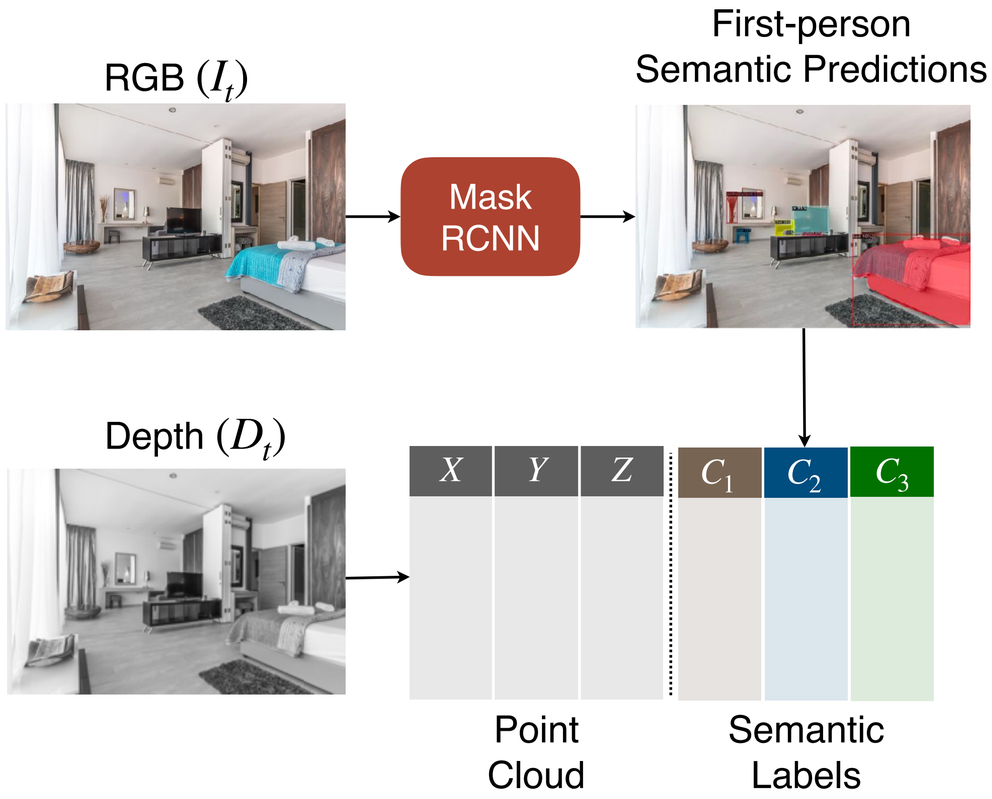
First-person Semantic Predictions

Depth (D_t)

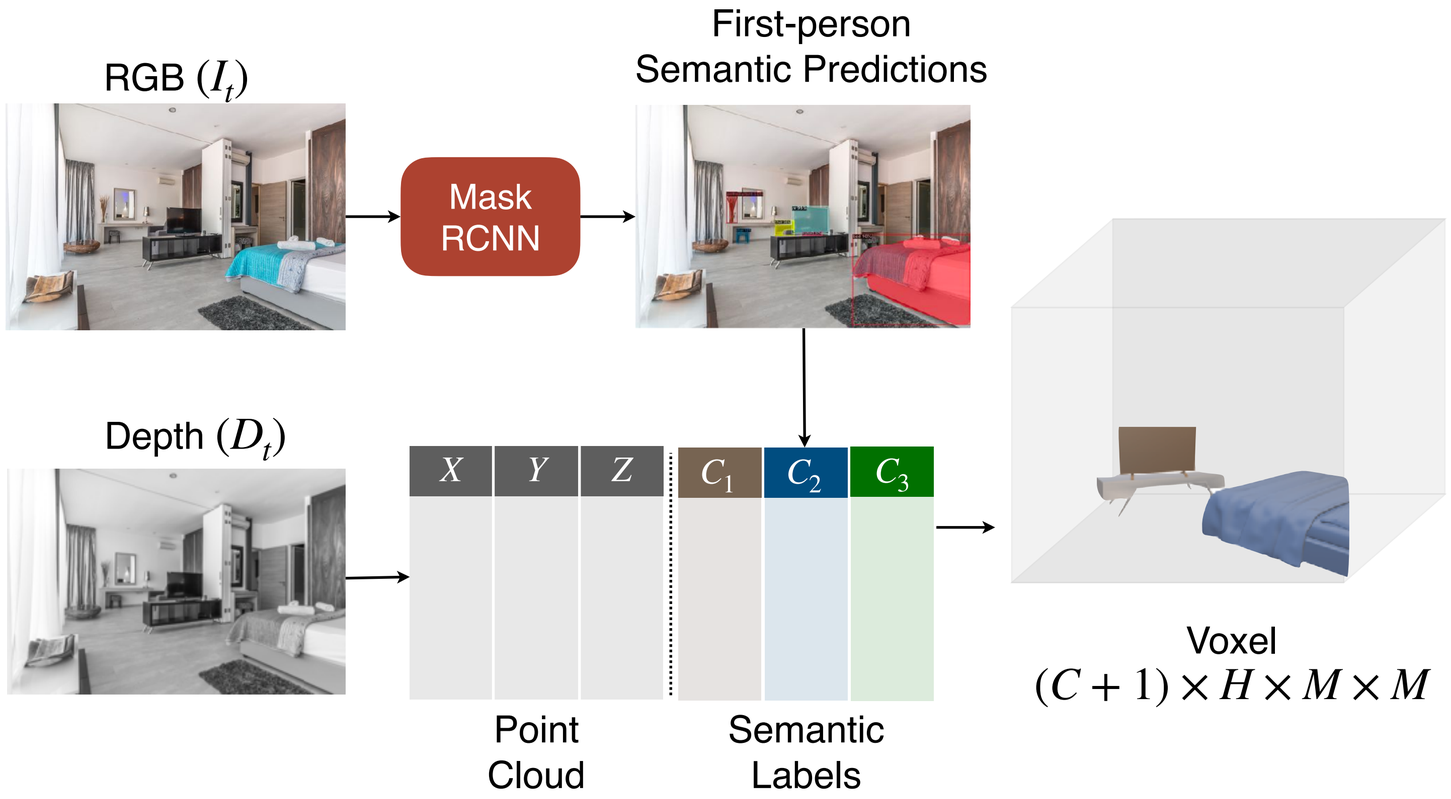
X	Y	Z

Point Cloud

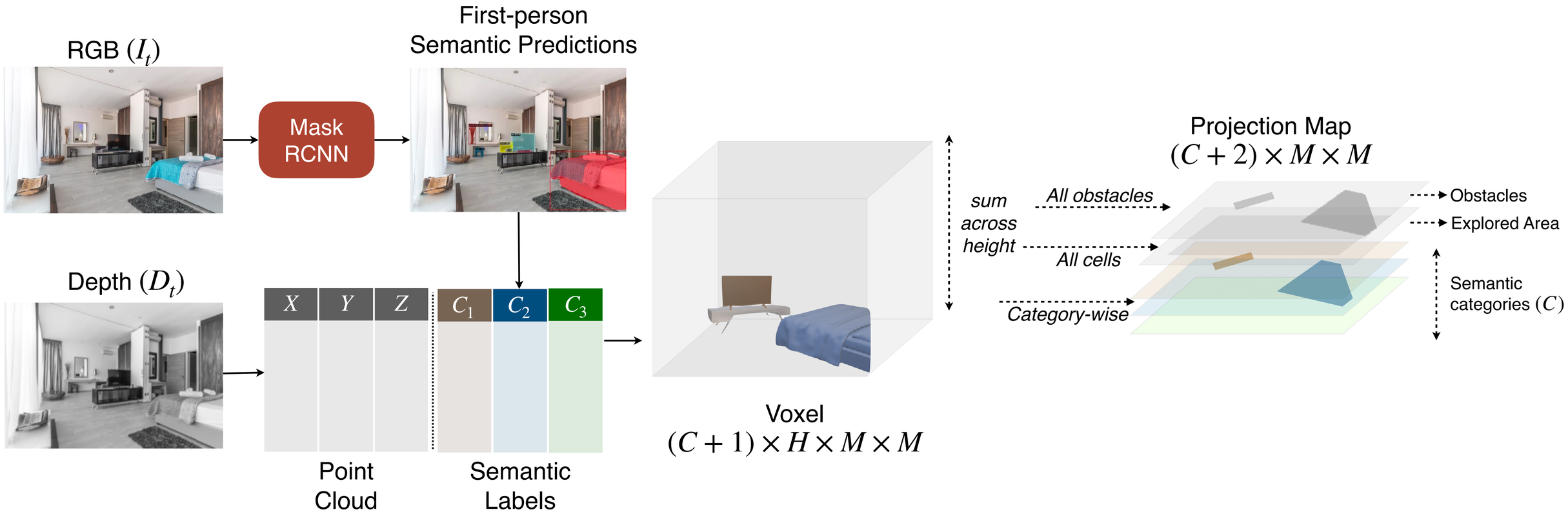
Semantic Mapping



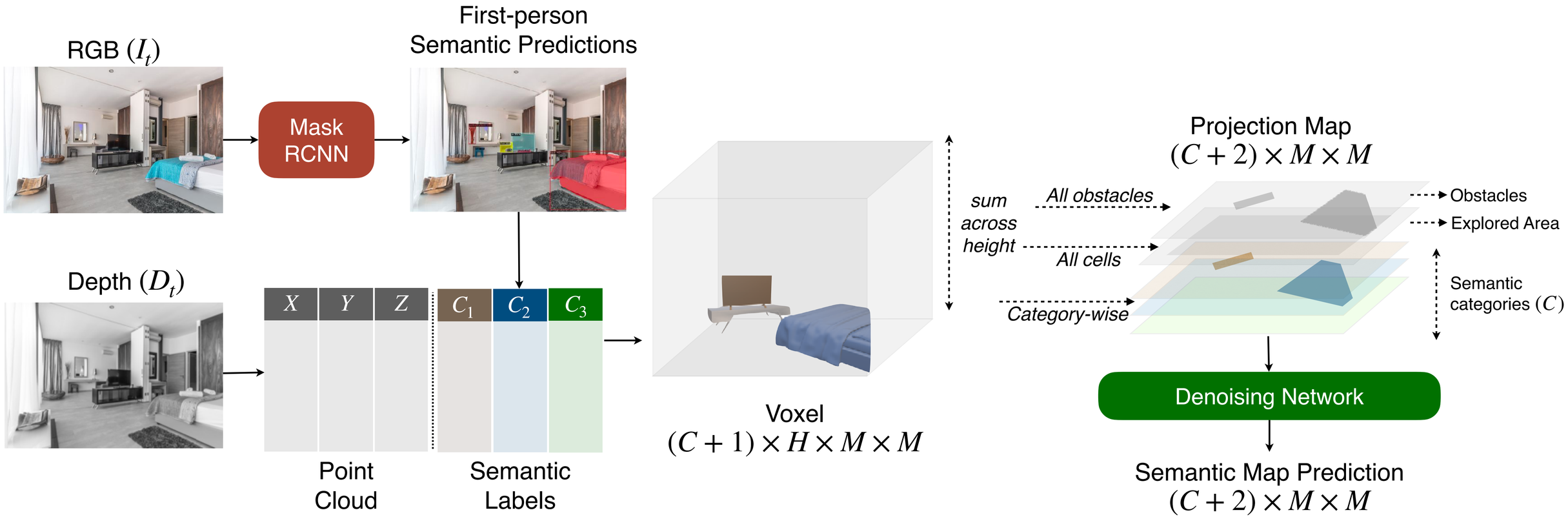
Semantic Mapping



Semantic Mapping



Semantic Mapping



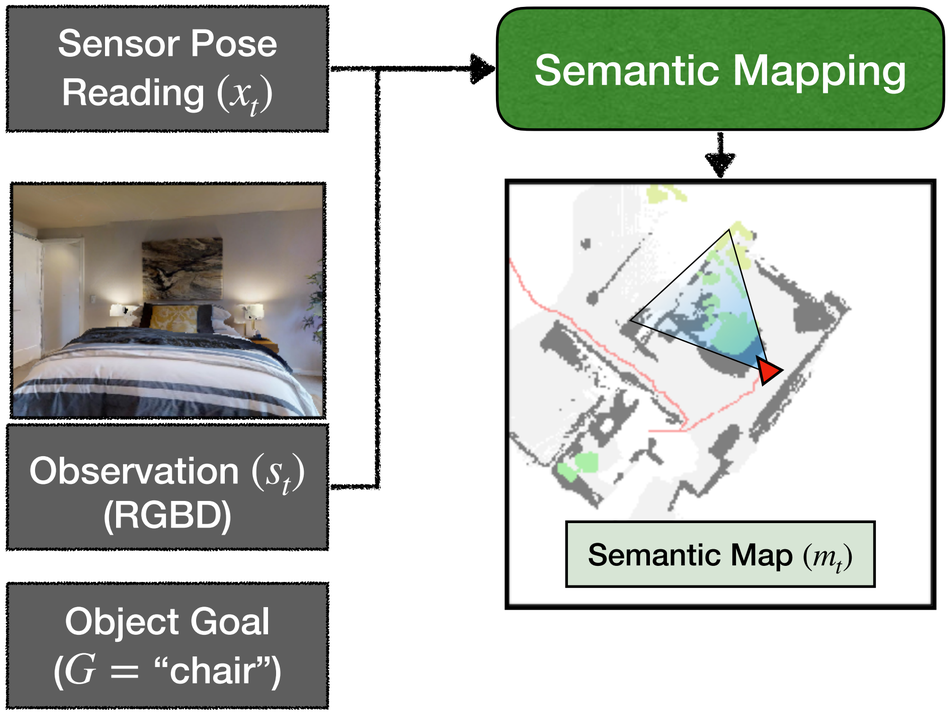
SemExp Model Overview

Sensor Pose Reading (x_t)

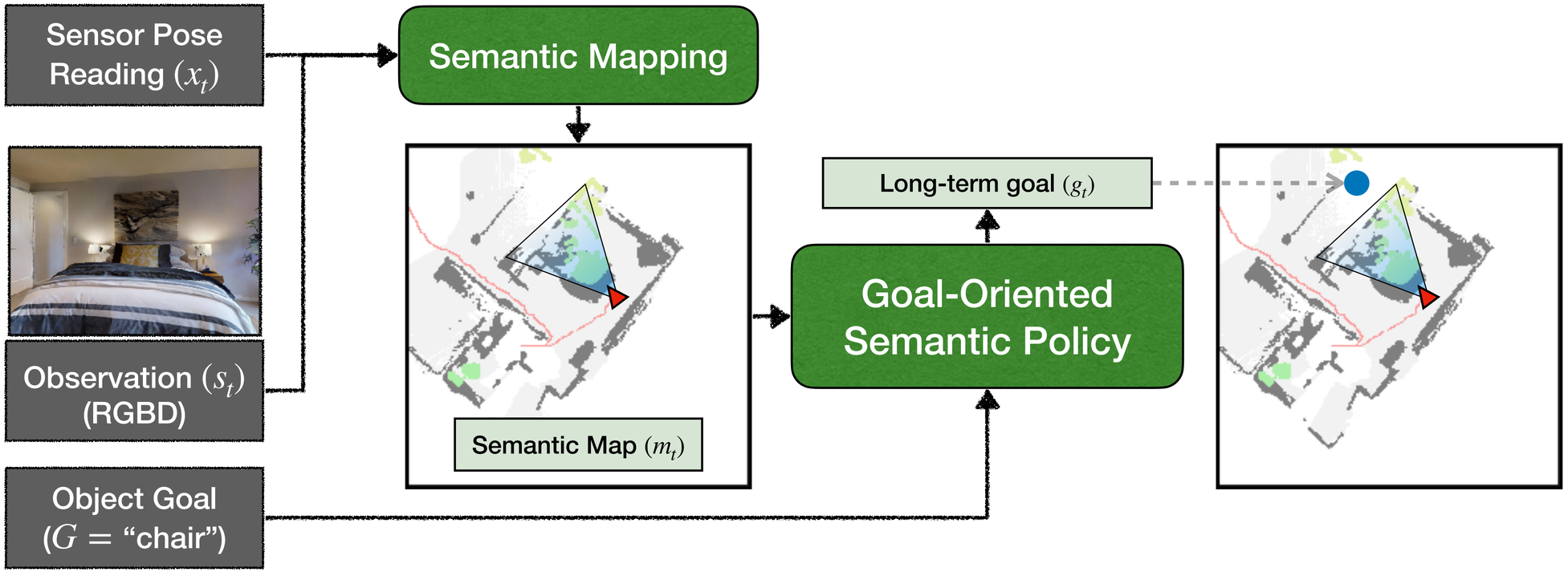
Observation (s_t) (RGBD)

Object Goal (G = “chair”)

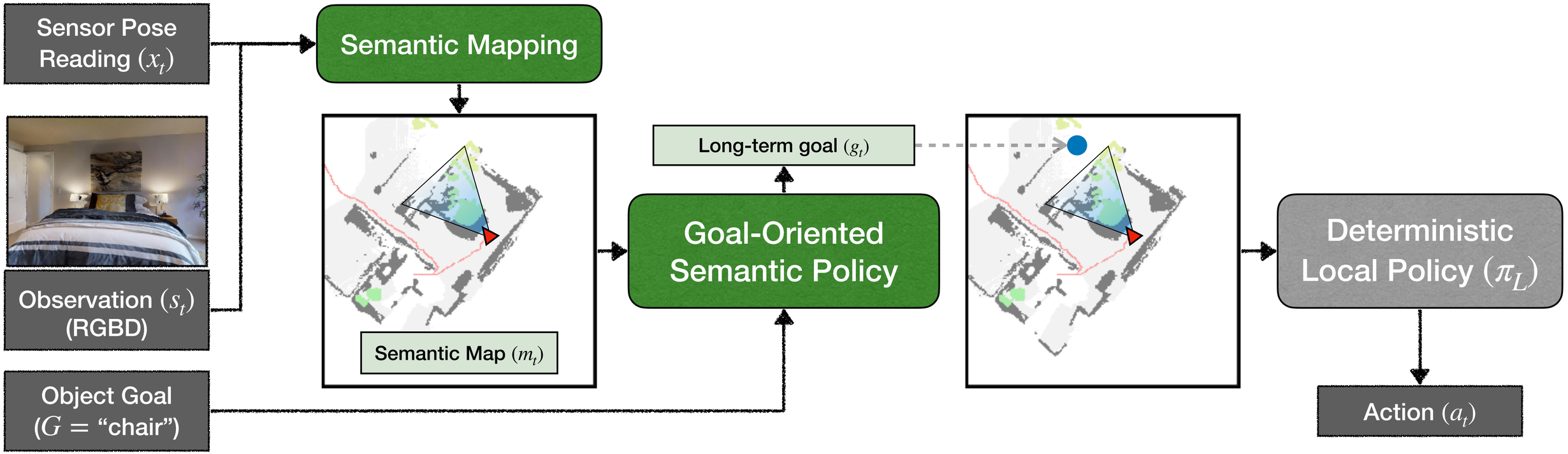
SemExp Model Overview



SemExp Model Overview

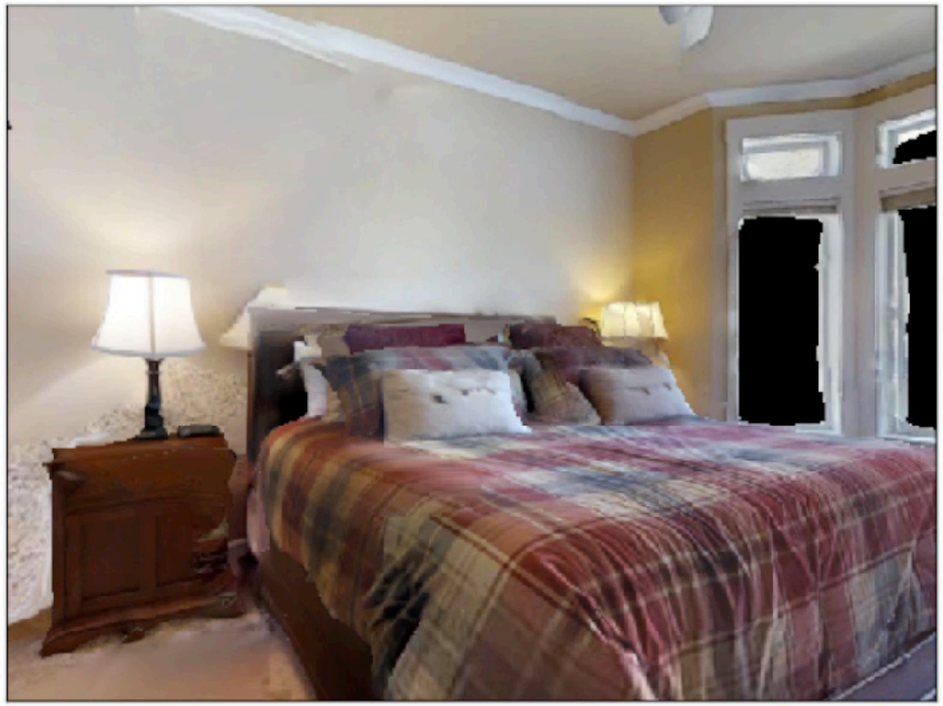


SemExp Model Overview



Demo Video

Observation (Goal: bed)



Predicted Semantic Map

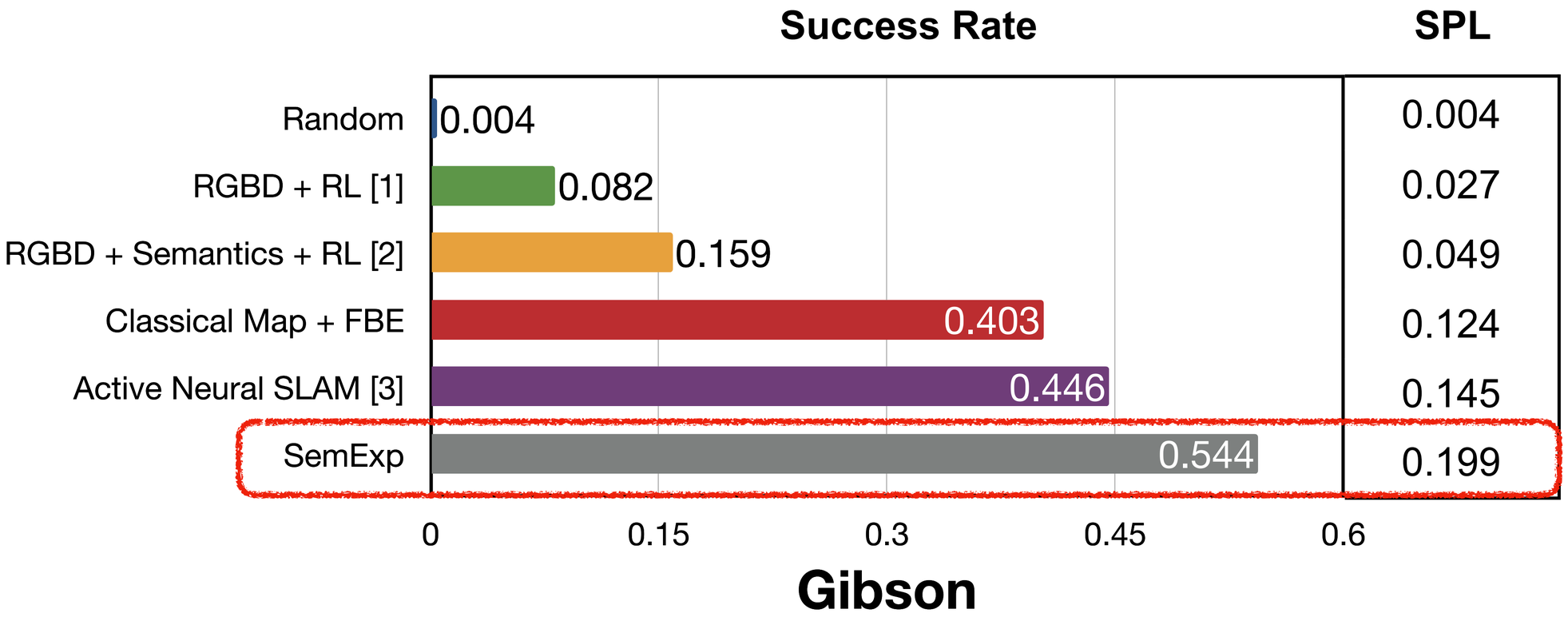
Ground Truth

Navigable Area
0: chair
1: couch
2: potted plant
3: bed
4: toilet
5: tv
6: dining-table
7: oven
8: sink
9: refrigerator
10: book
11: clock
12: vase
13: cup
14: bottle

https://youtu.be/h56dA2uxpGU

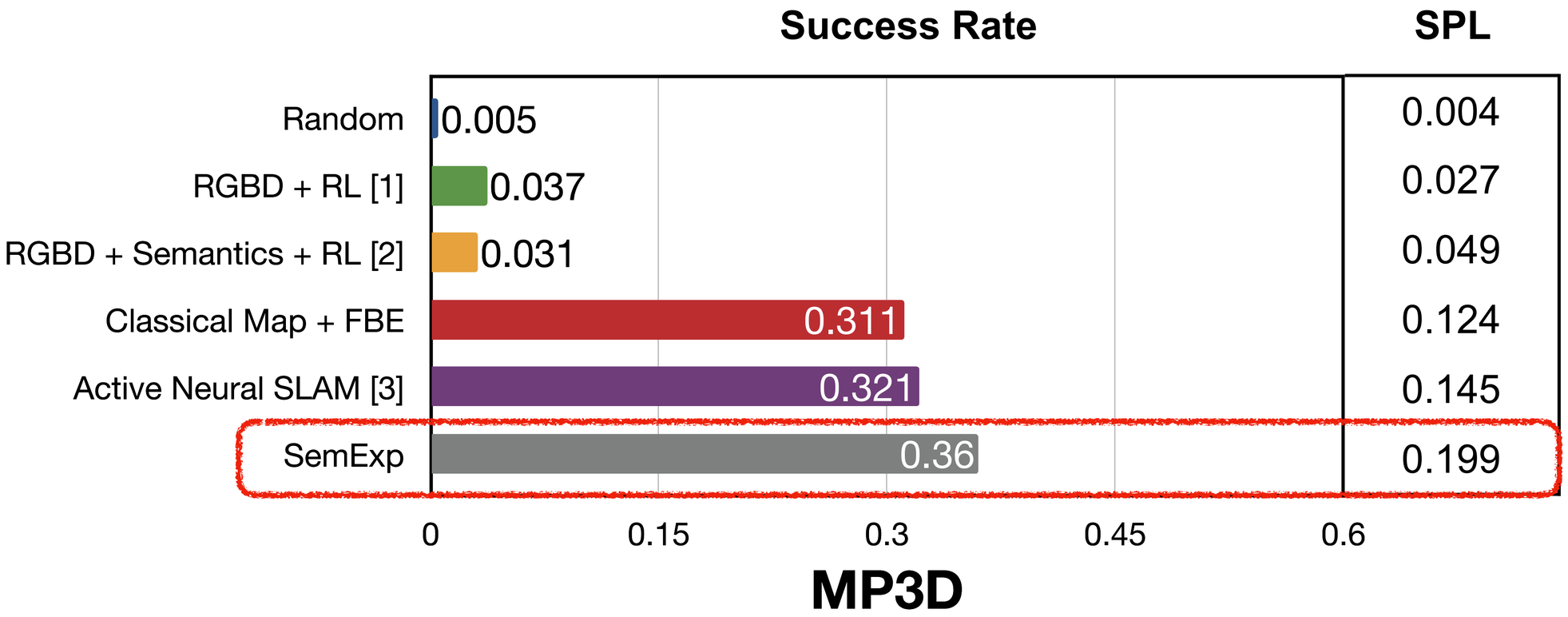
ObjectGoal Navigation Results

ObjectGoal Navigation Results



**Adapted from [1] Savva et al. ICCV-19, [2] Mousavian et al. ICRA-19, [3] Chaplot el al. ICLR-20*

ObjectGoal Navigation Results



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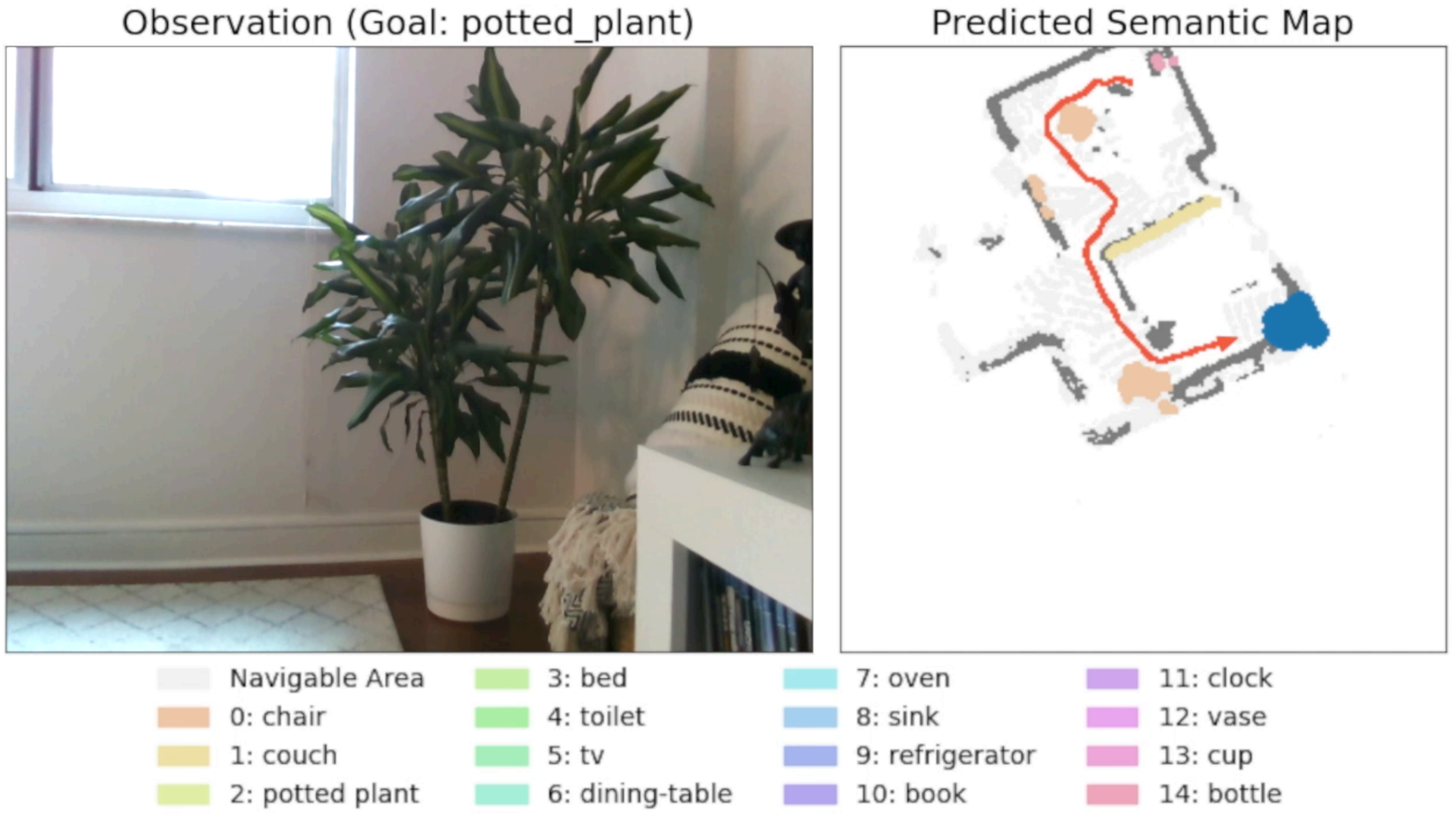
Habitat Challenge Leaderboard

	Test-standard			Minival		
Method	**SPL**	**Success**	**Dist**	**SPL**	**Success**	**Dist**
Arnold (SemExp)	**0.071**	**0.179**	**8.818**	**0.246**	**0.467**	**3.334**
Active Exploration	0.041	0.089	9.461	0.108	0.167	5.079
DD-PPO	0.021	0.062	9.316	-	-	-
Blue Ox	0.017	0.060	8.903	0.083	0.133	4.254
SRCB-robot-sudoer	0.002	0.004	10.276	0.124	0.233	4.848
PPO RGBD	-	-	-	0	0	6.055
Random	0.000	0.000	10.330	0	0	6.379

Real-world Transfer



See video at https://devendrachaplot.github.io/projects/semantic-exploration

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Devendra Singh Chaplot, Dhiraj Gandhi, Abhinav Gupta, Ruslan Salakhutdinov

CVPR 2020

Webpage: https://devendrachaplot.github.io/projects/semantic-exploration

Thank you

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