



# GOAT: GO to Any Thing

Matthew Chang\*, Theophile Gervet\*, Mukul Khanna\*, Sriram Yenamandra\*, Dhruv Shah, Tiffany Min, Kavit Shah, Chris Paxton, Saurabh Gupta, Dhruv Batra, Rozbeh Mottaghi, Jitendra Malik\*, Devendra Singh Chaplot\*

- 1. GOAT Problem**
- 2. GOAT System Architecture**
- 3. Results**
- 4. Applications**
  - a. Pick & Place**
  - b. Social Navigation**
  - c. Platform Agnostic**

**Unknown Environment**  
*Explore*

**Perception**  
*Detect and Localize  
Objects*

**Lifelong Memory**  
*Remember Object  
Locations*

**Control**  
*Navigate to / Pick & Place  
Objects*



# Multimodal:

Reach Any Object Specified in Any Way

Image



Language

*Find **the fruit basket** on the kitchen counter*

Category

*Bring me a CUP*

# Lifelong:

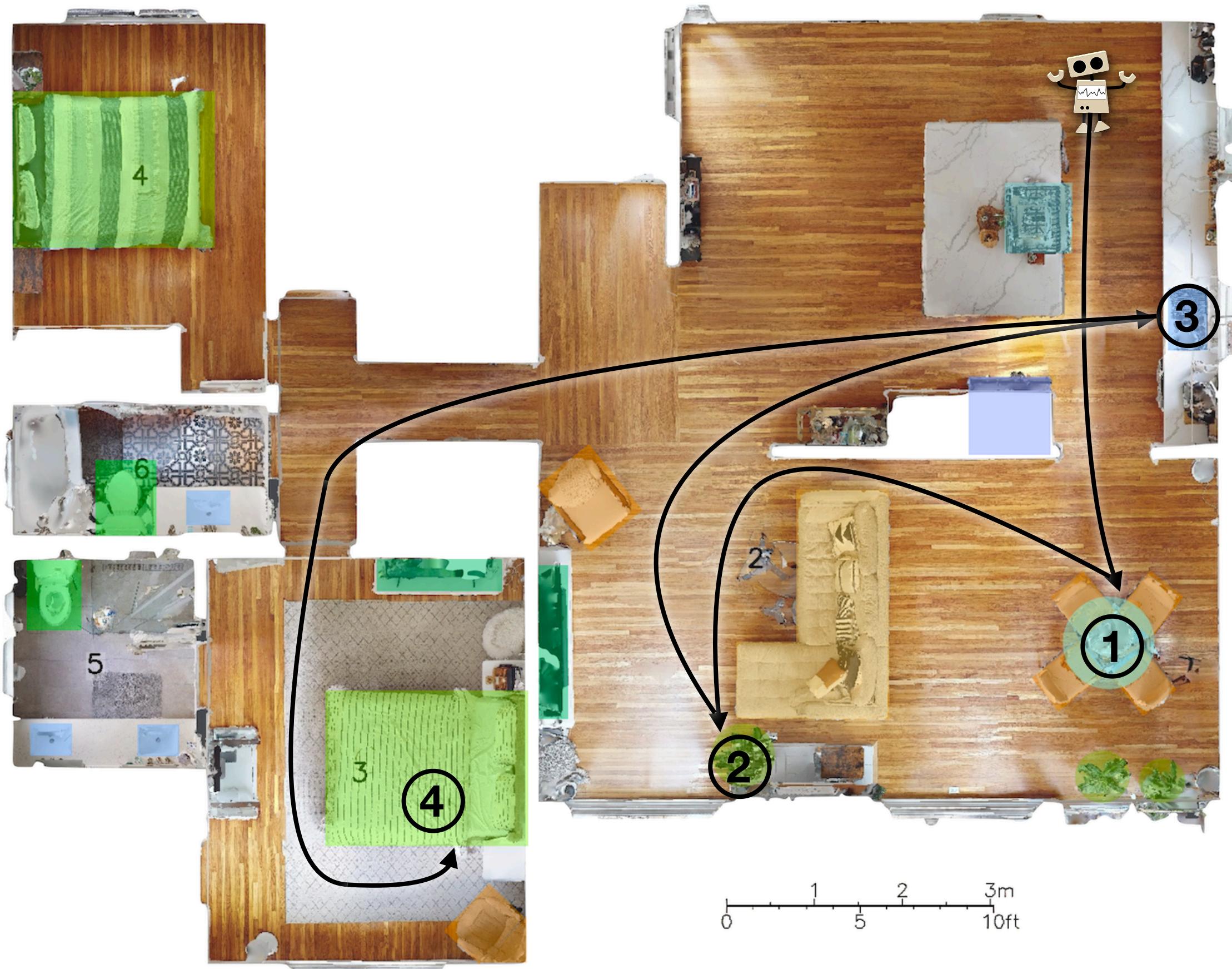
Remember Object Locations



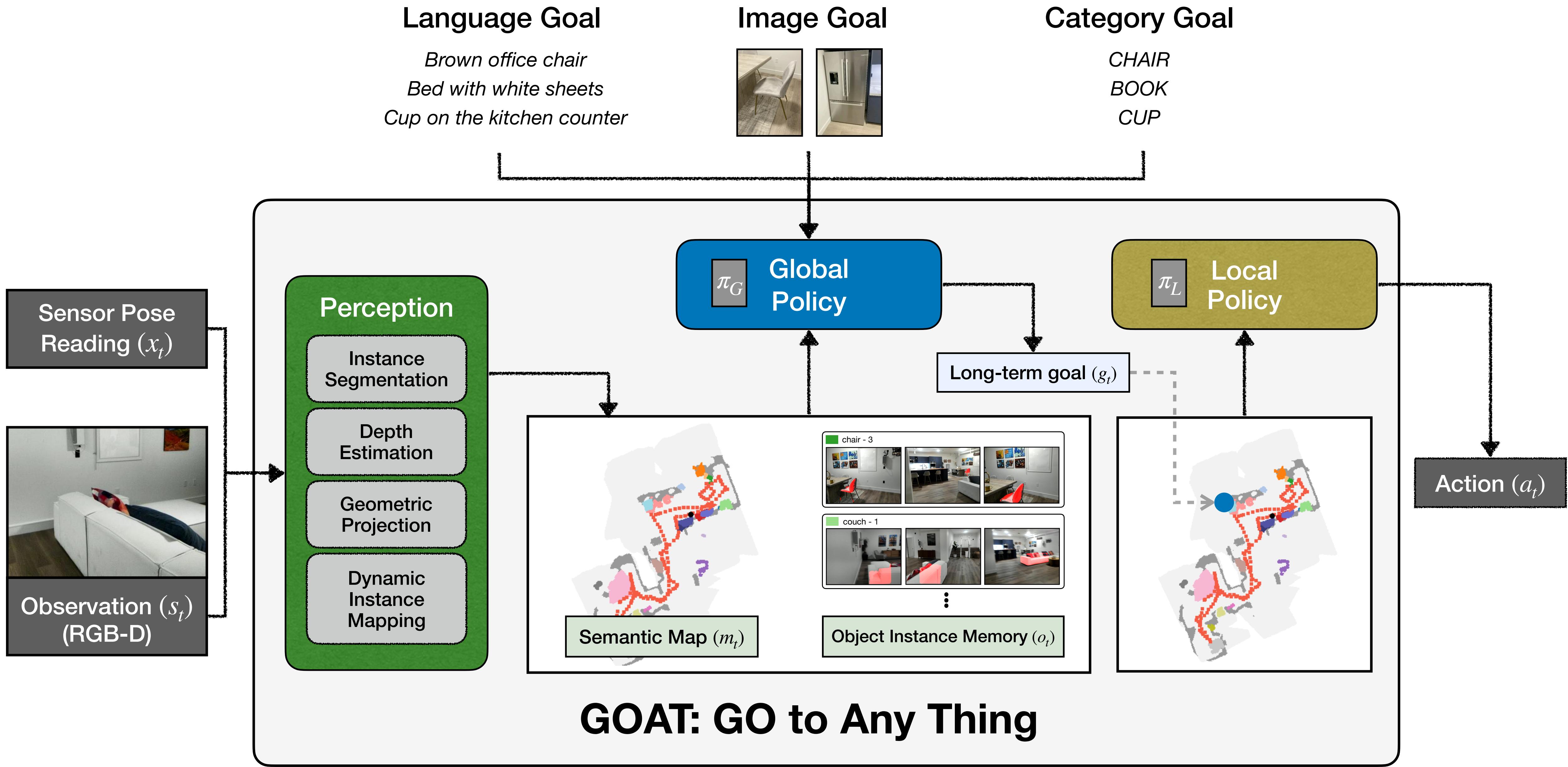
② Go to the potted plant next to the couch

③ Go to a SINK

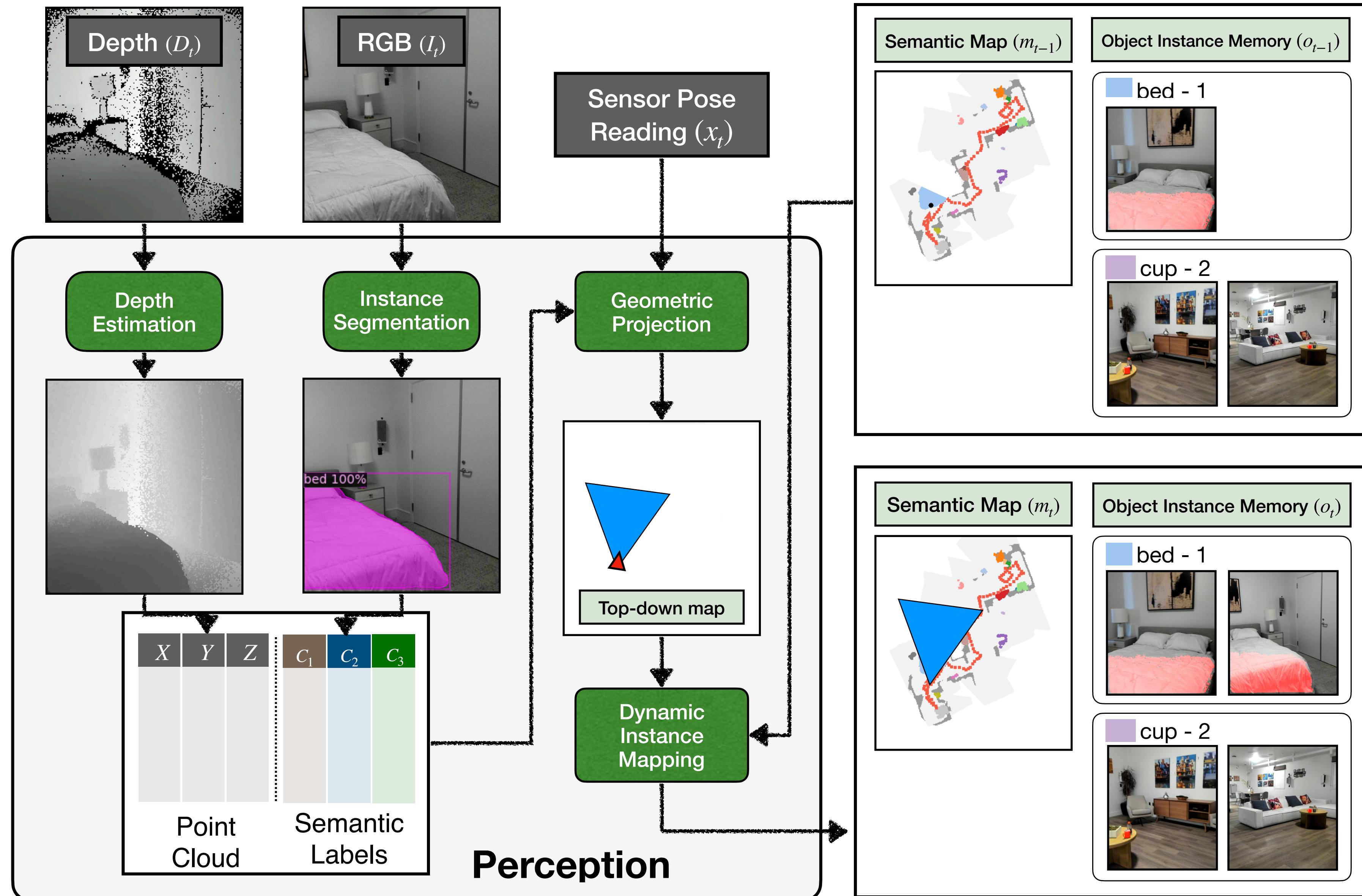
④ Go to the black and white striped bed



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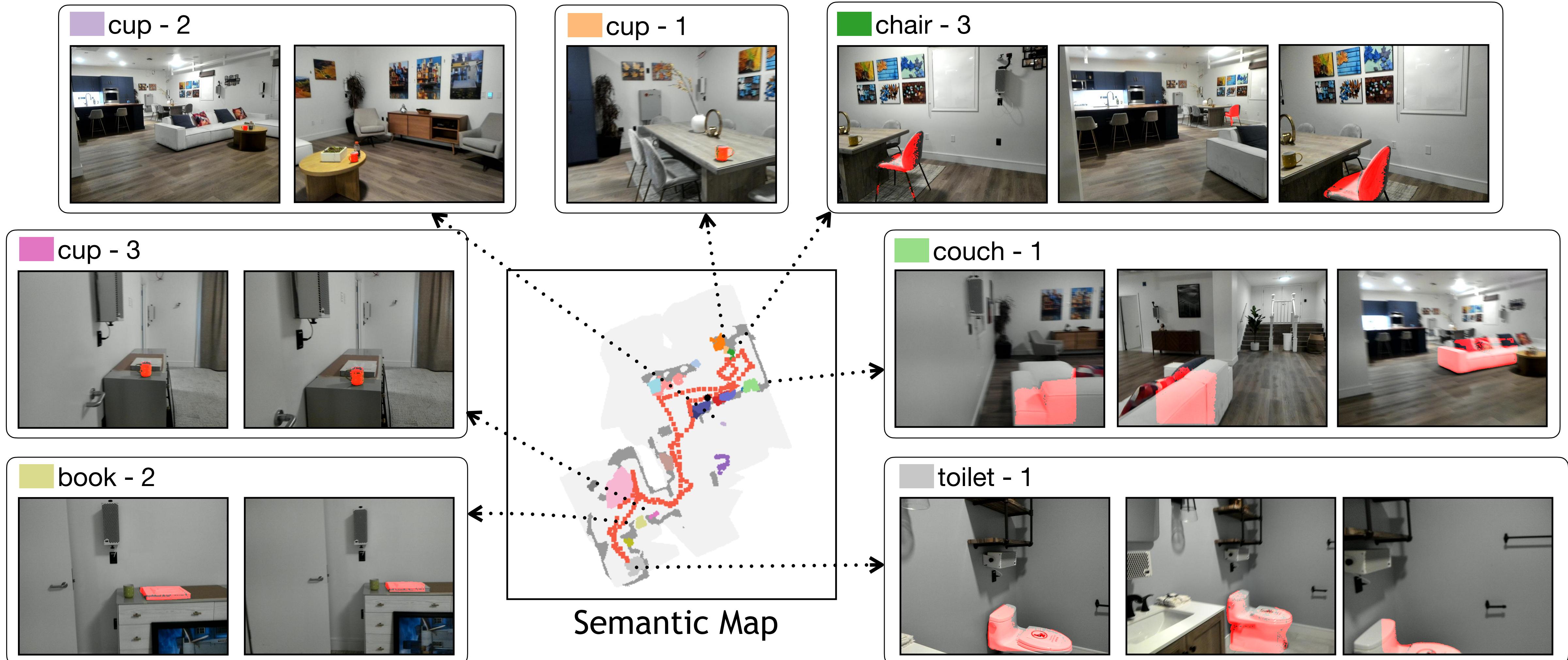


# Perception System

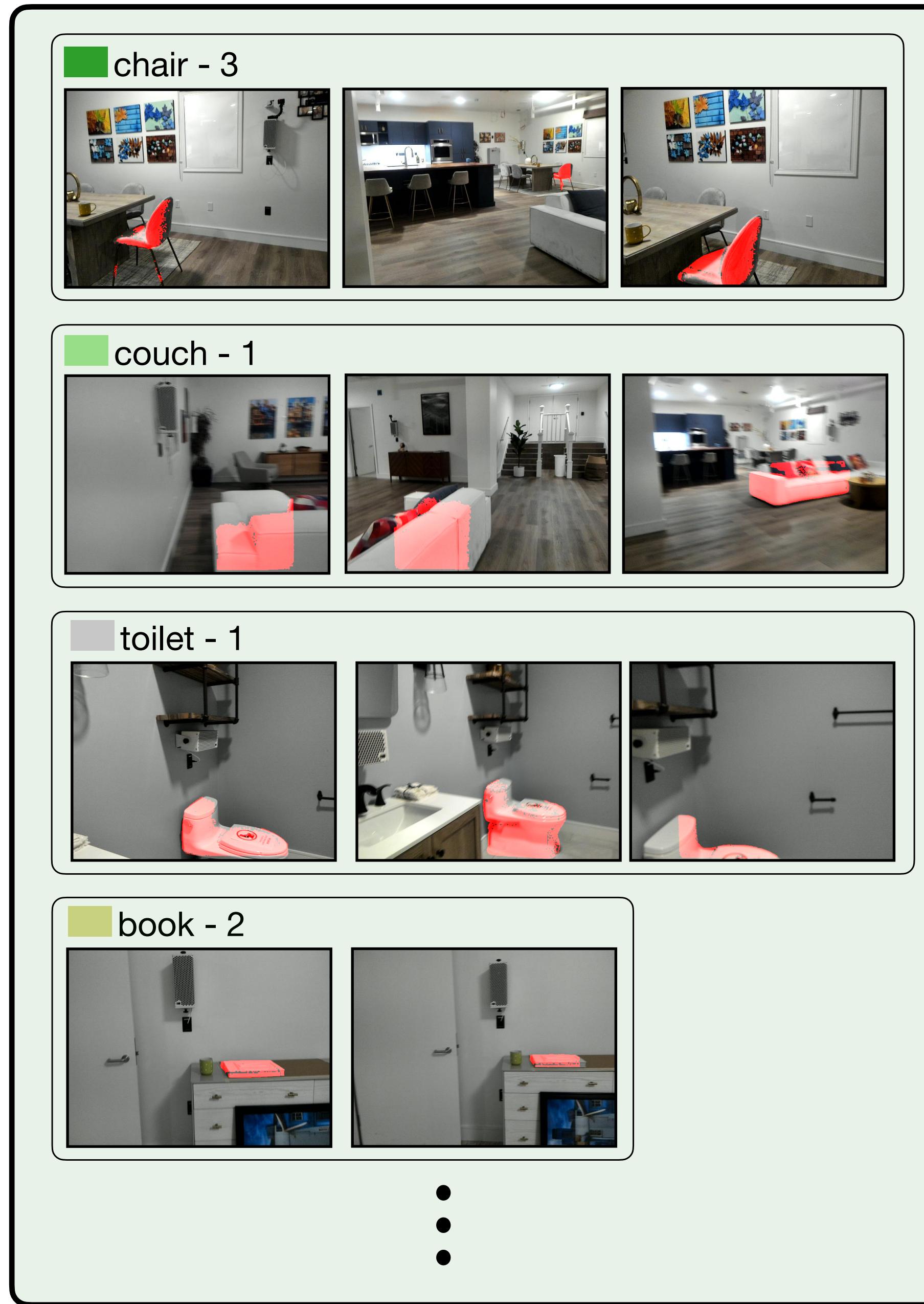


# GOAT Memory Representation

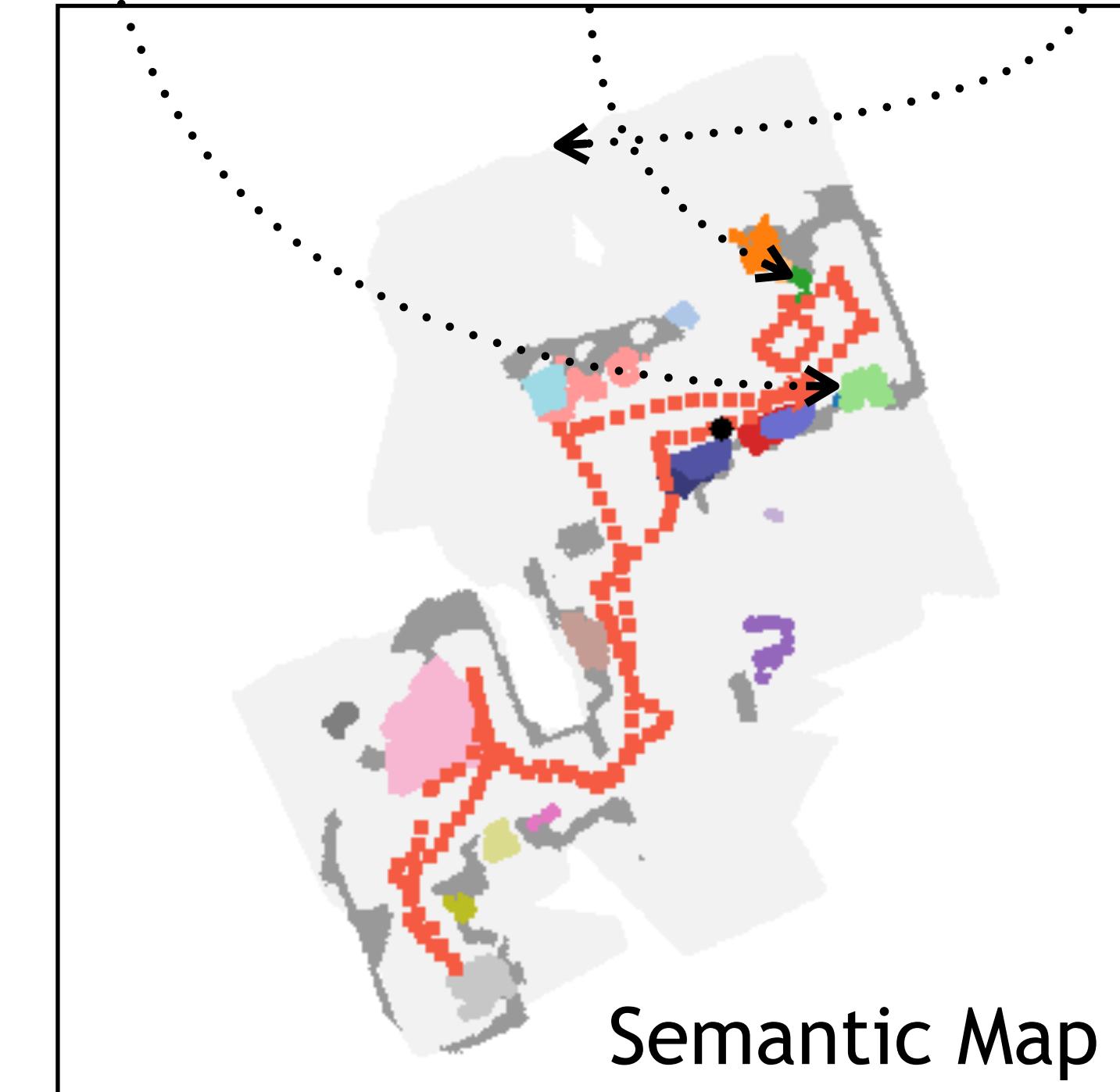
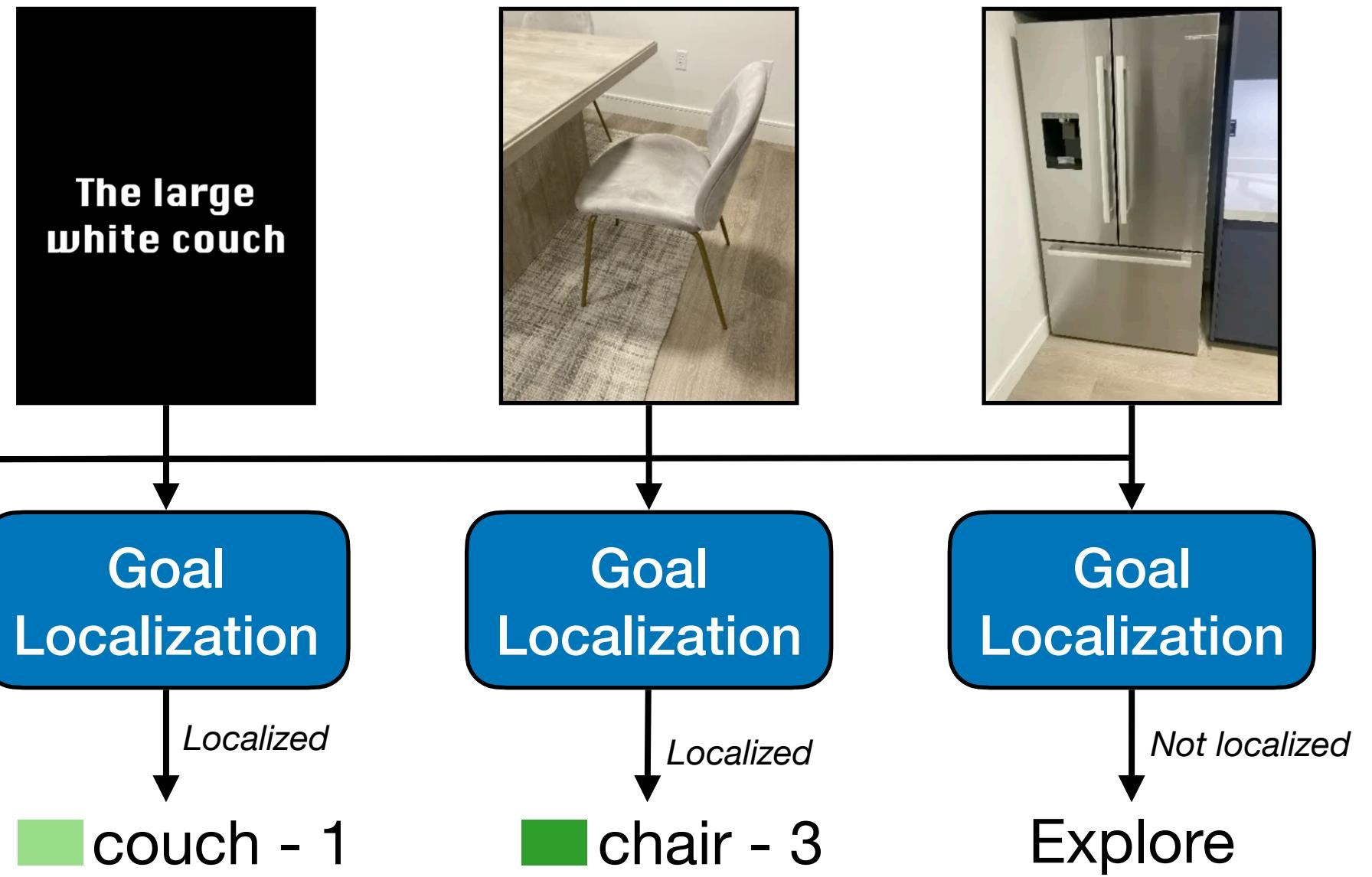
*Semantic map with associated Object Instance memory*



## Object Instance Memory



## Goals



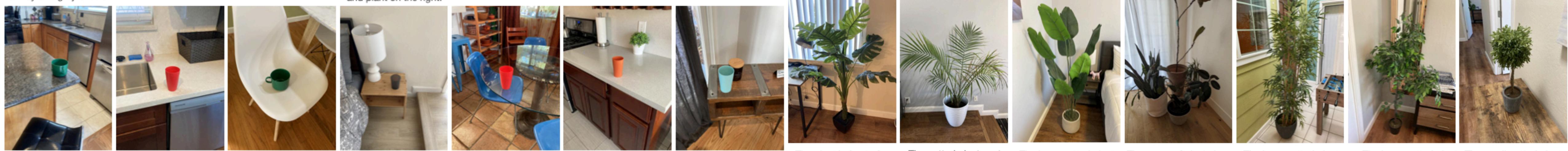
Semantic Map

- 1. GOAT Problem**
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**“In the Wild”**  
**Empirical Evaluation**  
*9 Unseen Homes*  
**4 Methods**  
*10 Trajectories per Home*  
*5-10 Goals per Trajectory*  
*~90h of Experiments*



The bed with the white blanket pulled back halfway and grey sheets.  
The bunk bed with stars on the blanket.  
The bed with blue and white sheets.  
The with the blue and yellow painting above it and plant on the right.  
The bed with the blue blanket and blue pillows.  
The bed with grey sheets and light green trim.  
The bed with the white blanket and red pillows  
The large grey living room couch with many pillows.  
The green couch.  
The white rectangular couch with no pillows.  
The large grey living room couch with many pillows.  
The light brown couch with blue pillows.  
The large grey couch in front of the yellow wall.  
The couch covered in a white blanket.



The green cup on the kitchen counter  
The red cup on the kitchen counter  
The green mug on the plastic chair.  
The grey cup on the nightstand.  
The red cup on top of the glass table.  
The red cup on the kitchen counter.  
The light blue cup.  
The plant in front of the window.  
The potted plant next to the stairs.  
The large potted plant in the bedroom.  
The group of plants in front of the curtain.  
The large potted plant next to the foosball table.  
The large potted plant in front of the mirror.  
The small potted plant on the hallway table



The grey dining table chair.  
The green lawn chair.  
The black office chair.  
The small wooden chair at the desk.  
The black leather chair at the desk.  
The bar-height chair at the kitchen island.  
a wooden seat.  
wood desk.  
the kitchen counter  
The light blue bowl on the living room coffee table.  
The lavender bowl on the kitchen counter.  
The light blue bowl on the couch.  
The green cover book on the coffee table.  
The book on the desk. It has a car on the cover.



The beige teddy bear.  
The stuffed lion toy.  
The green dinosaur stuffed toy.  
The stuffed lion.  
The beige teddy bear.  
The stuffed lion toy.  
The green dinosaur stuffed toy.  
The refrigerator.  
The refrigerator.  
The refrigerator.  
The toilet next to the shower curtain with blue fish.  
The toilet.  
The toilet next to the glass shower door.



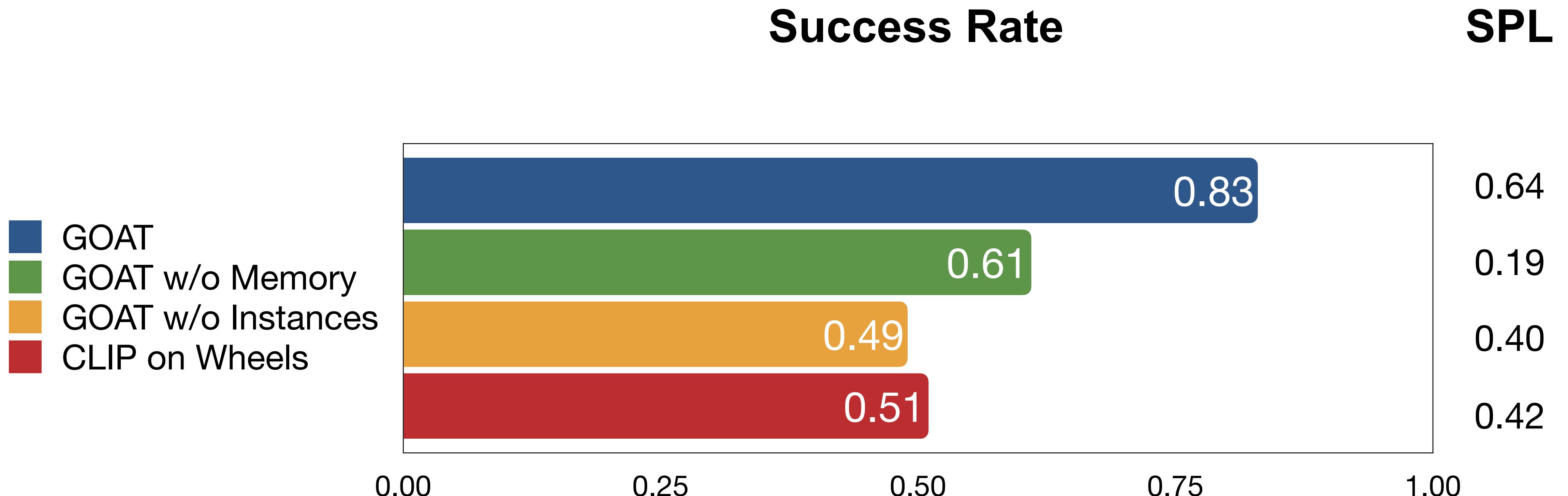
The kitchen sink.  
The bathroom sink with marble top.  
The kitchen sink.  
The kitchen sink with green counter.  
The bathroom sink.  
The kitchen sink.  
The bathroom sink with black and white counter.  
The television.  
The television mounted on a yellow wall.  
The television mounted on a white wall.  
The oven.  
The oven.  
The oven.  
The oven.

# "In the Wild"

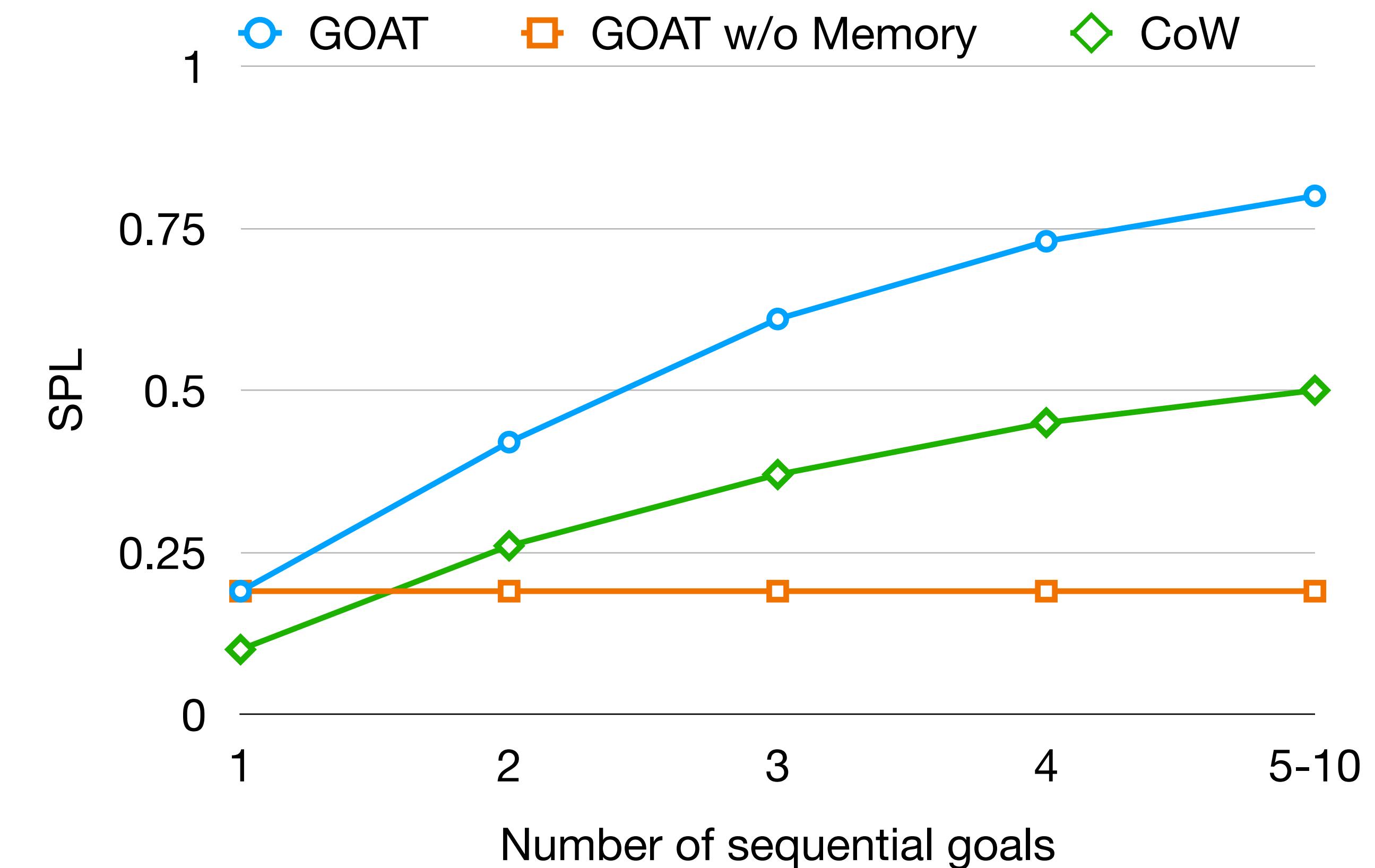
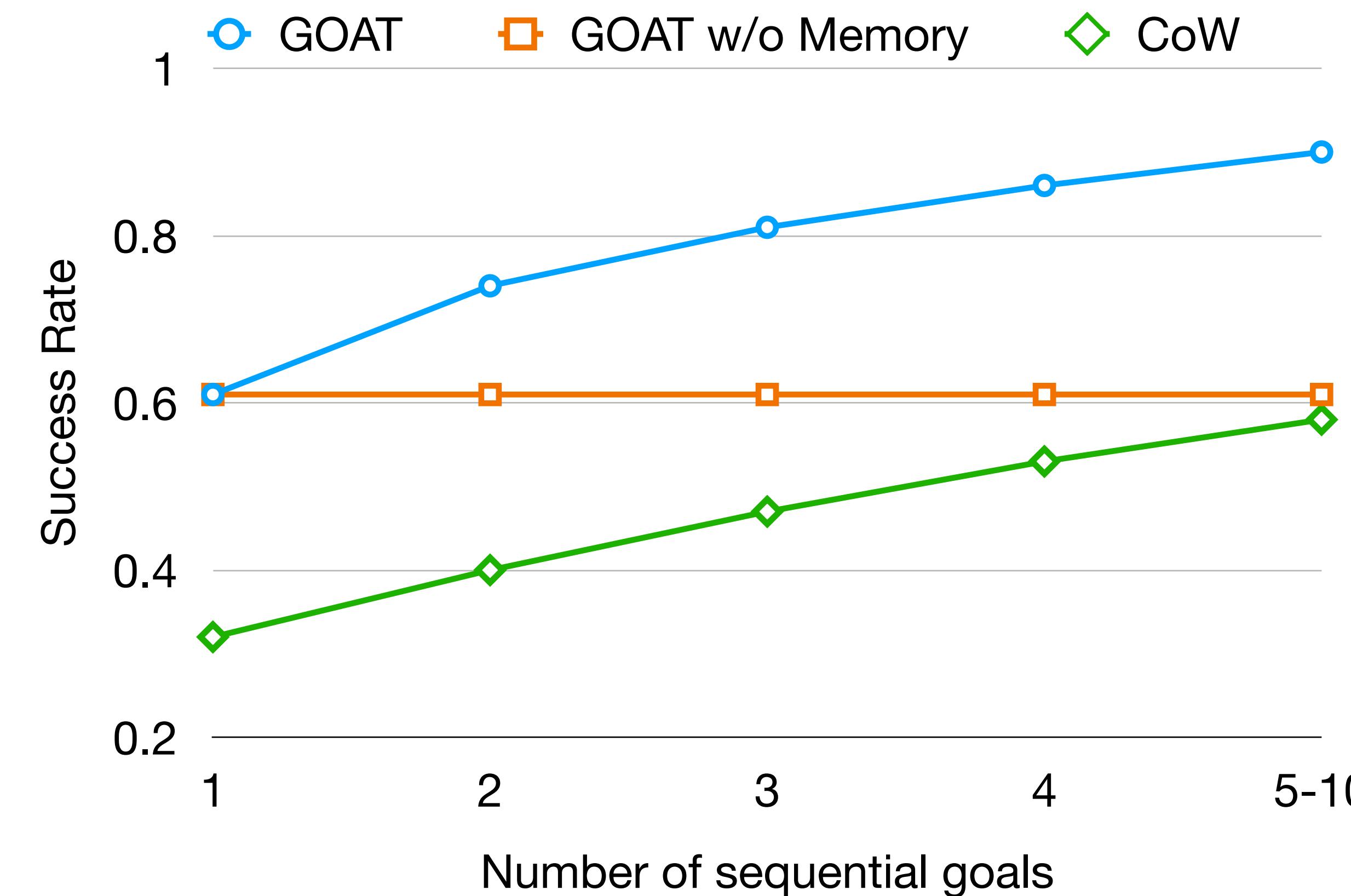
## Empirical Evaluation

### 200+ Object Instances

# Results



# Performance Across Episode

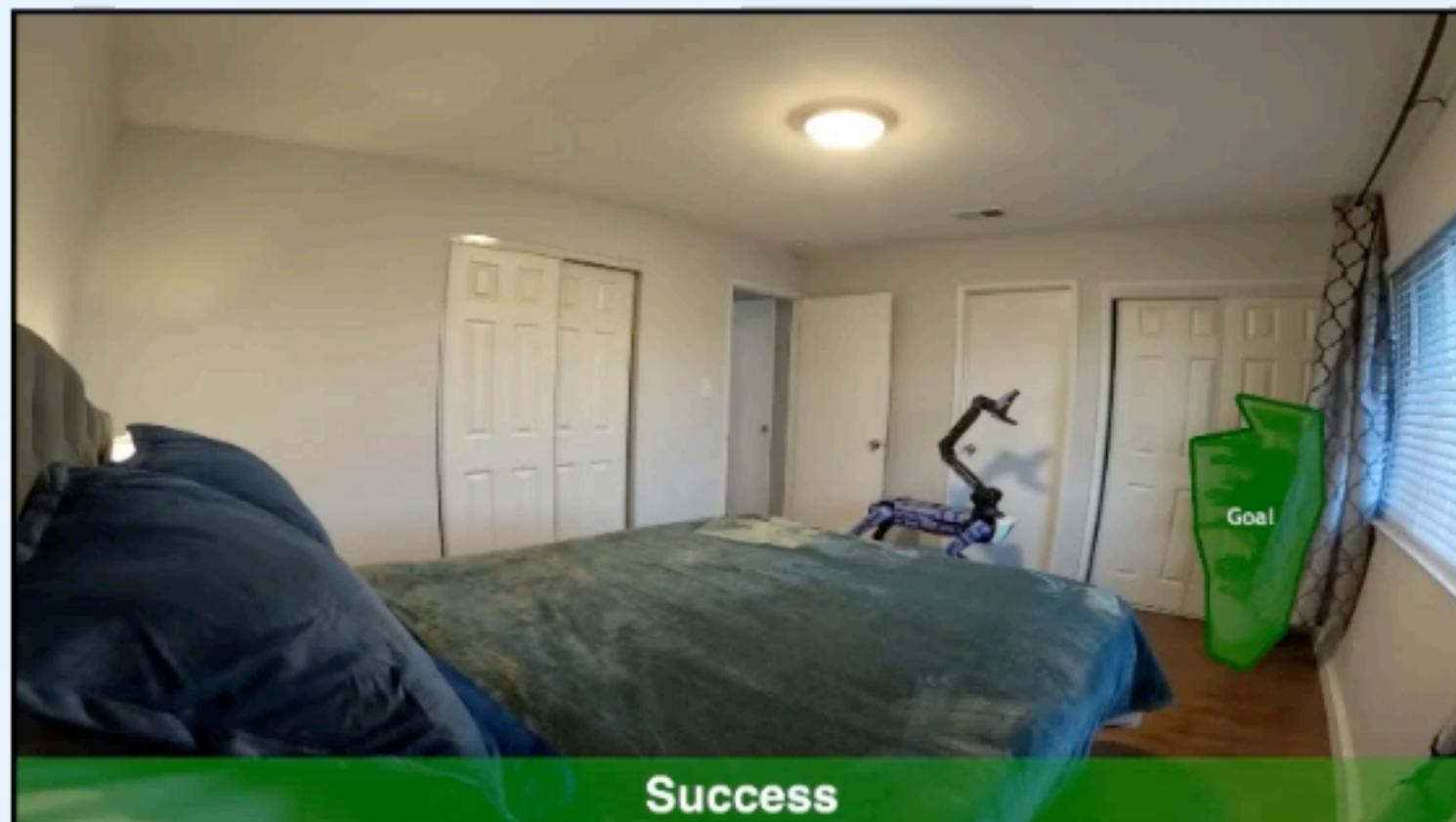


Goal:



# Baselines

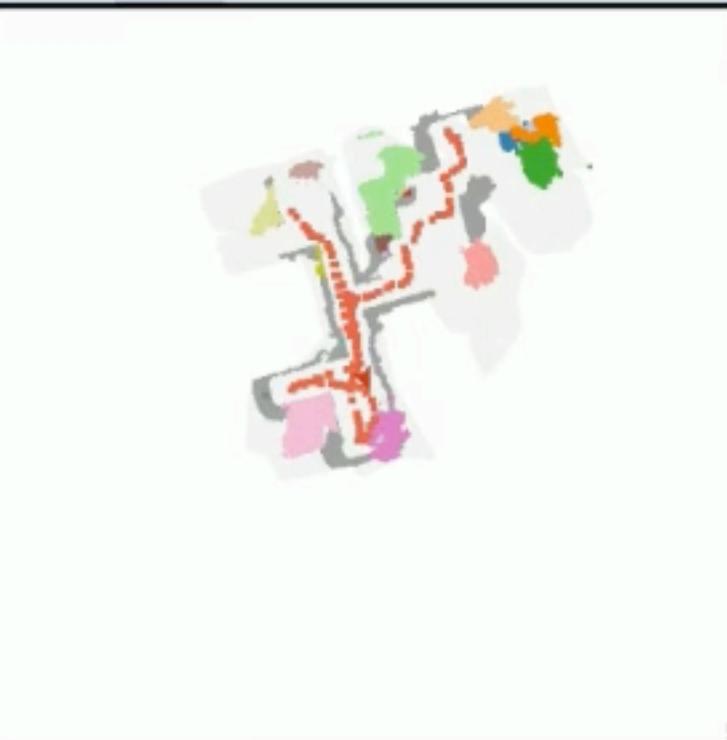
Ours



Success

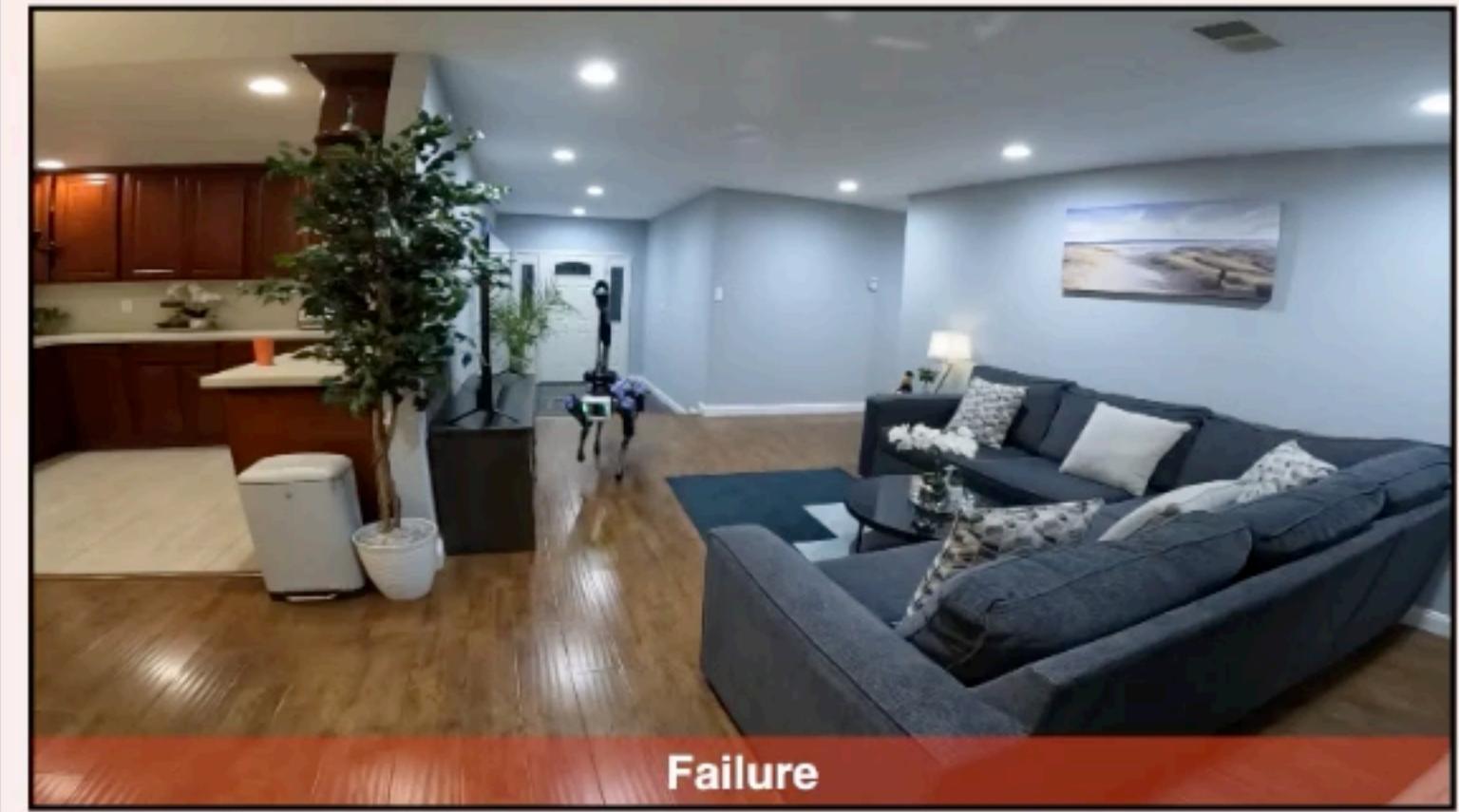


Observation



Instance Map

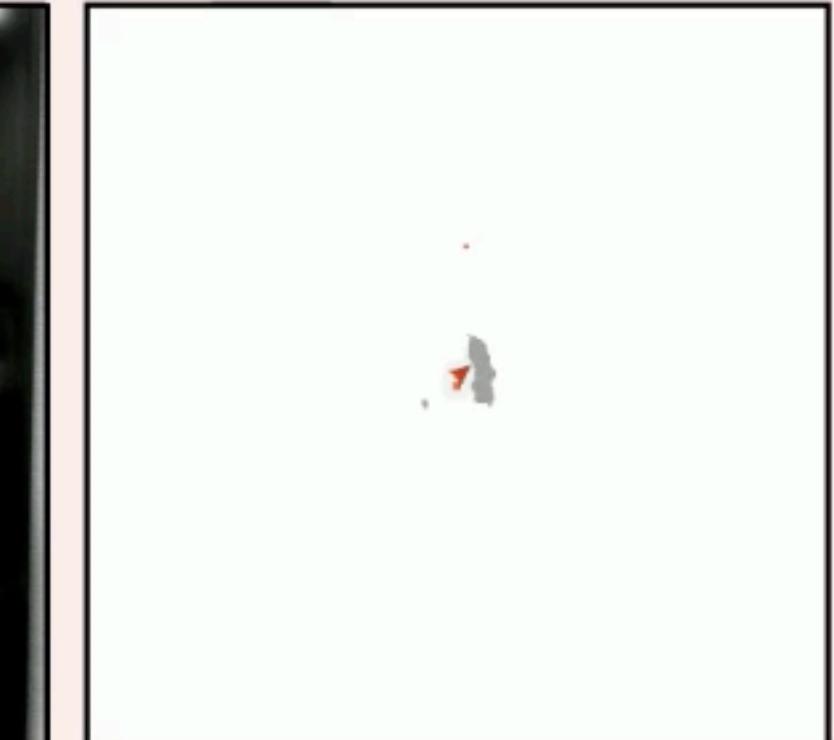
No Memory



Failure

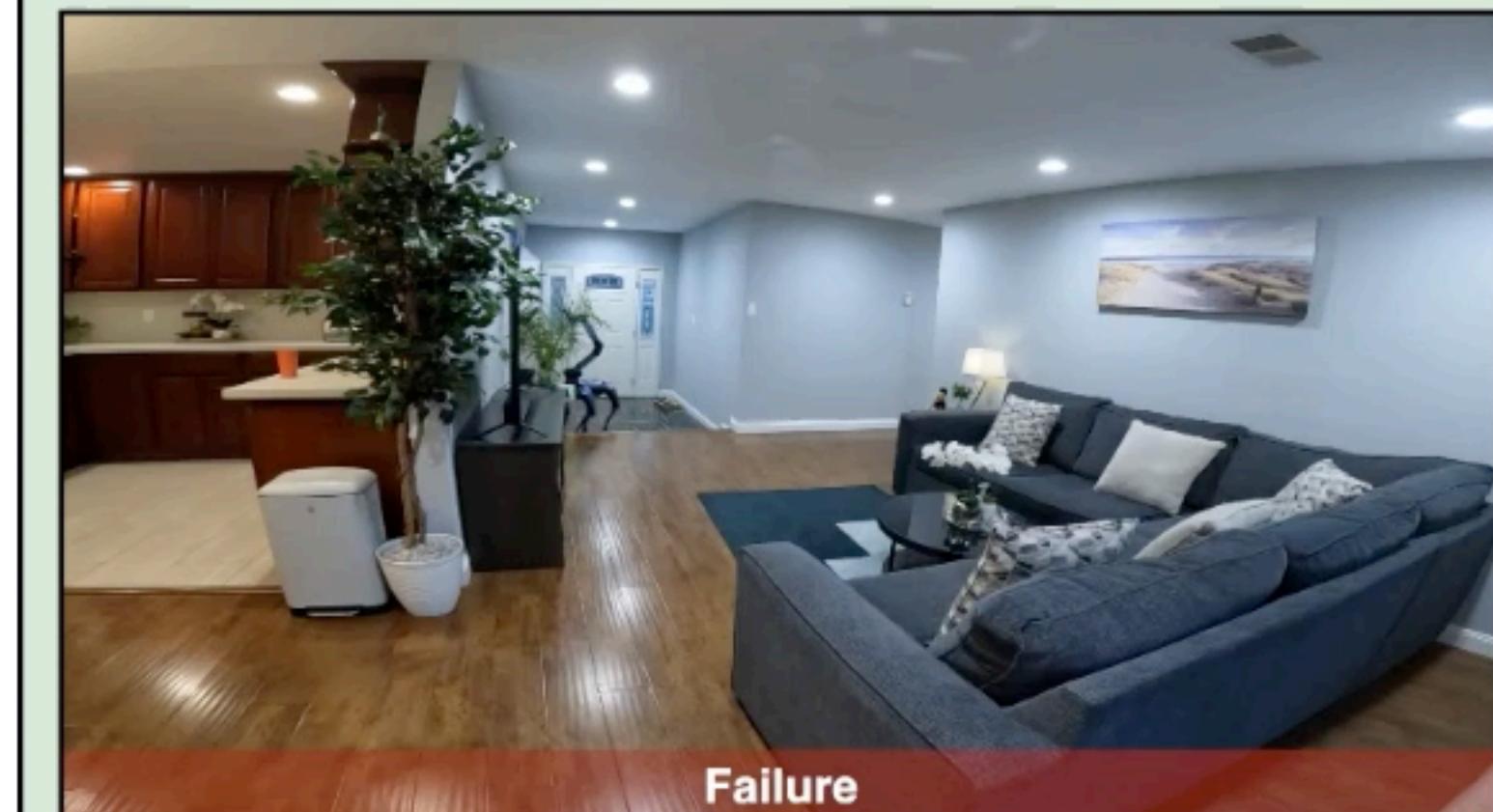


Observation

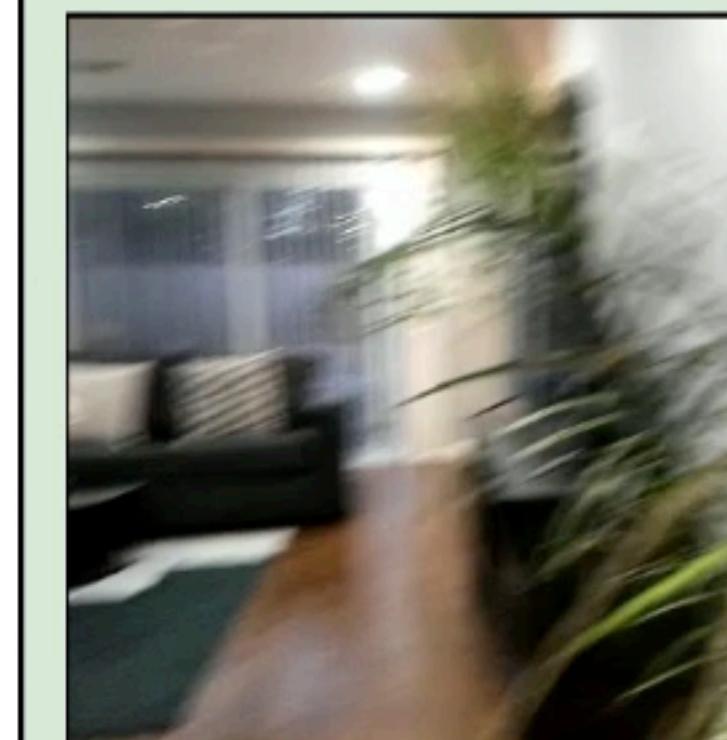


Instance Map

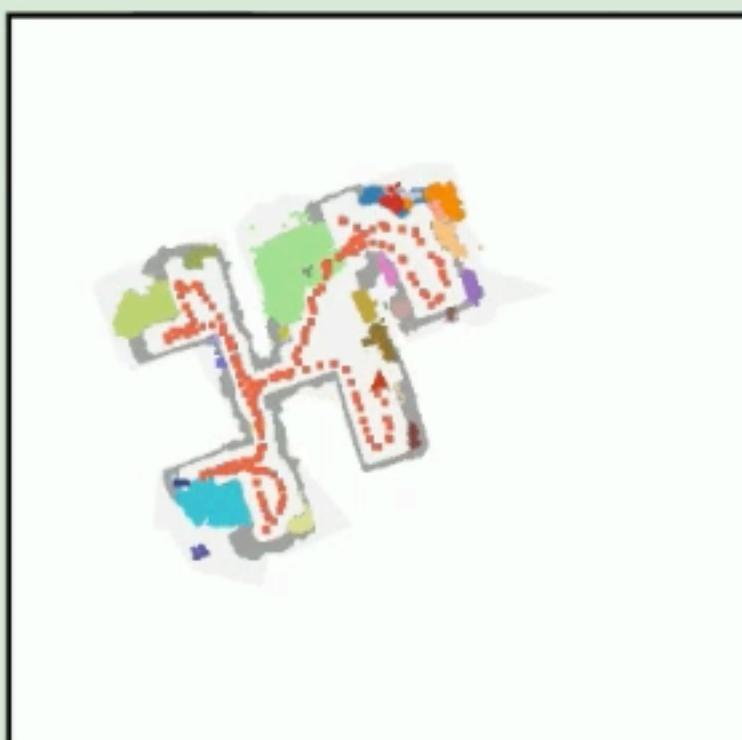
CoW



Failure



Observation



Instance Map

Success: 6/6 SPL: 0.78

Success: 4/6 SPL: 0.40

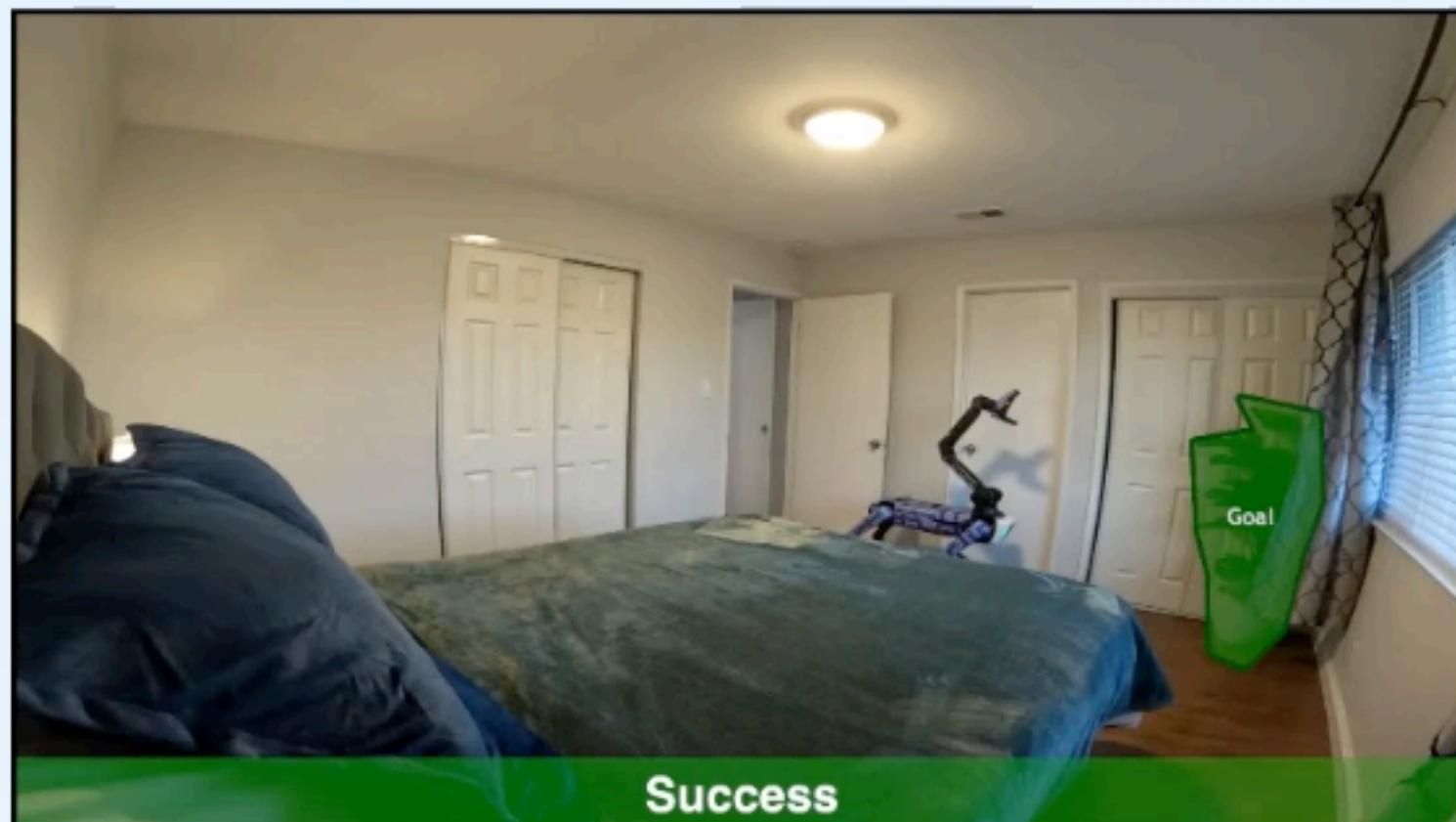
Success: 1/6 SPL: 0.16

Goal:



# Baselines

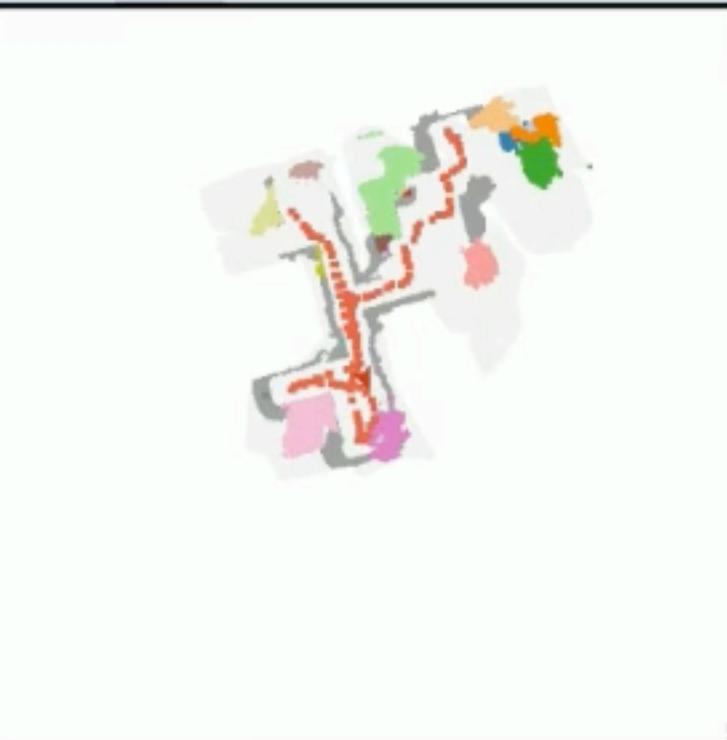
Ours



Success

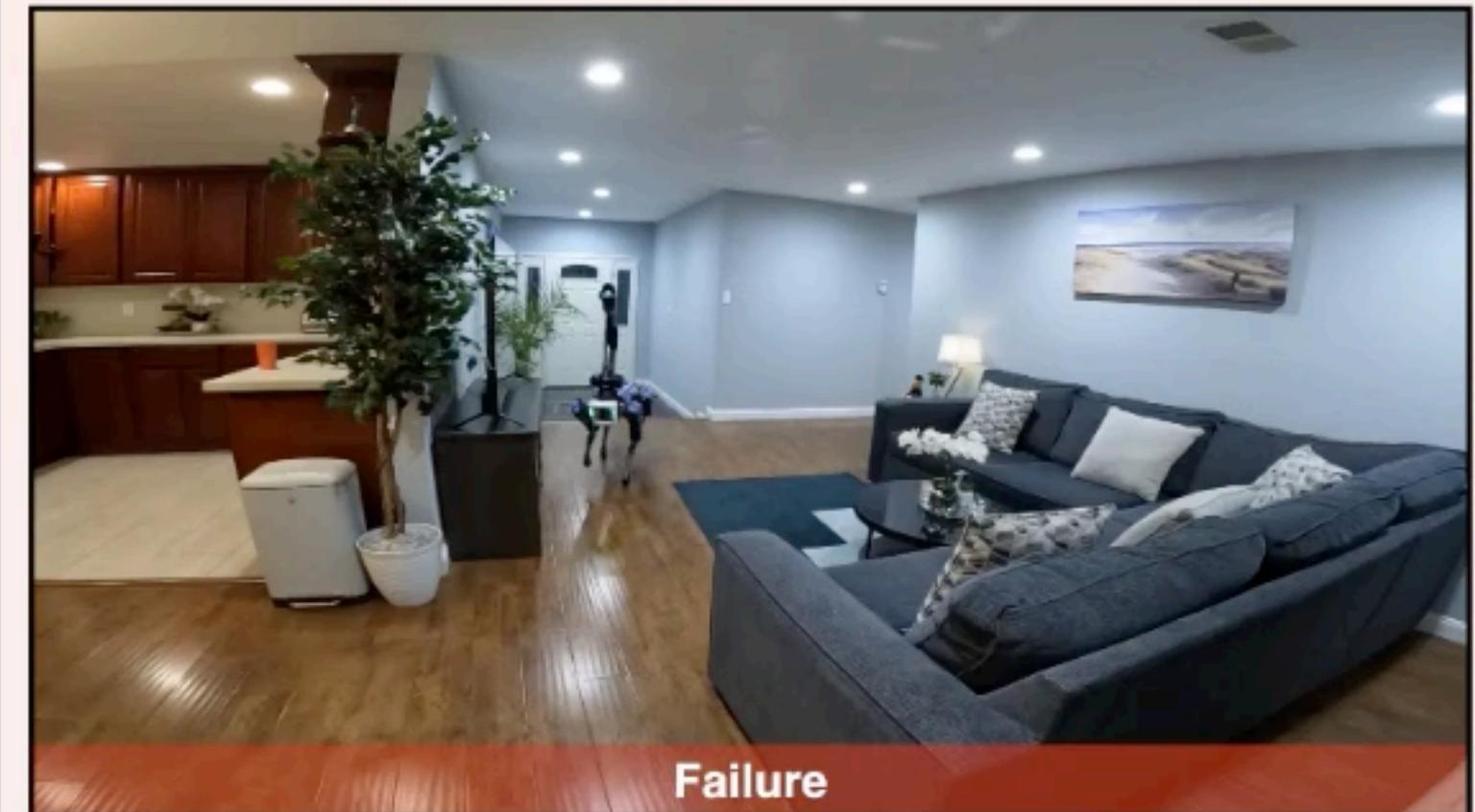


Observation

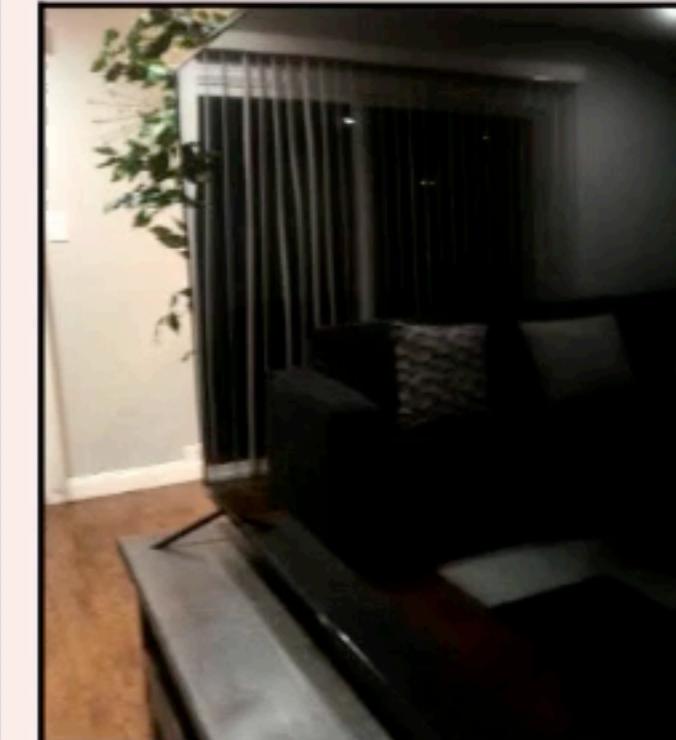


Instance Map

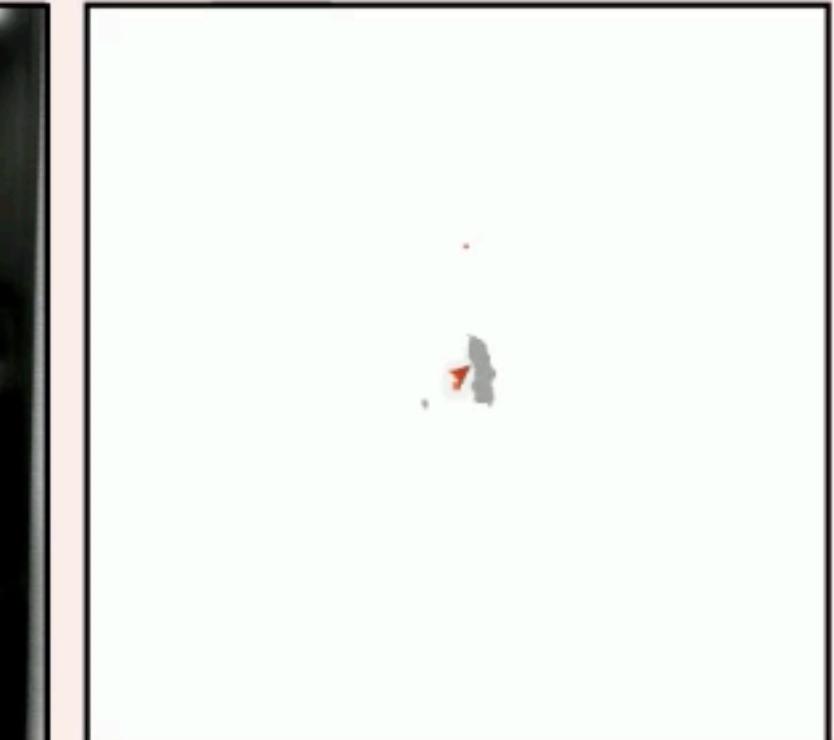
No Memory



Failure

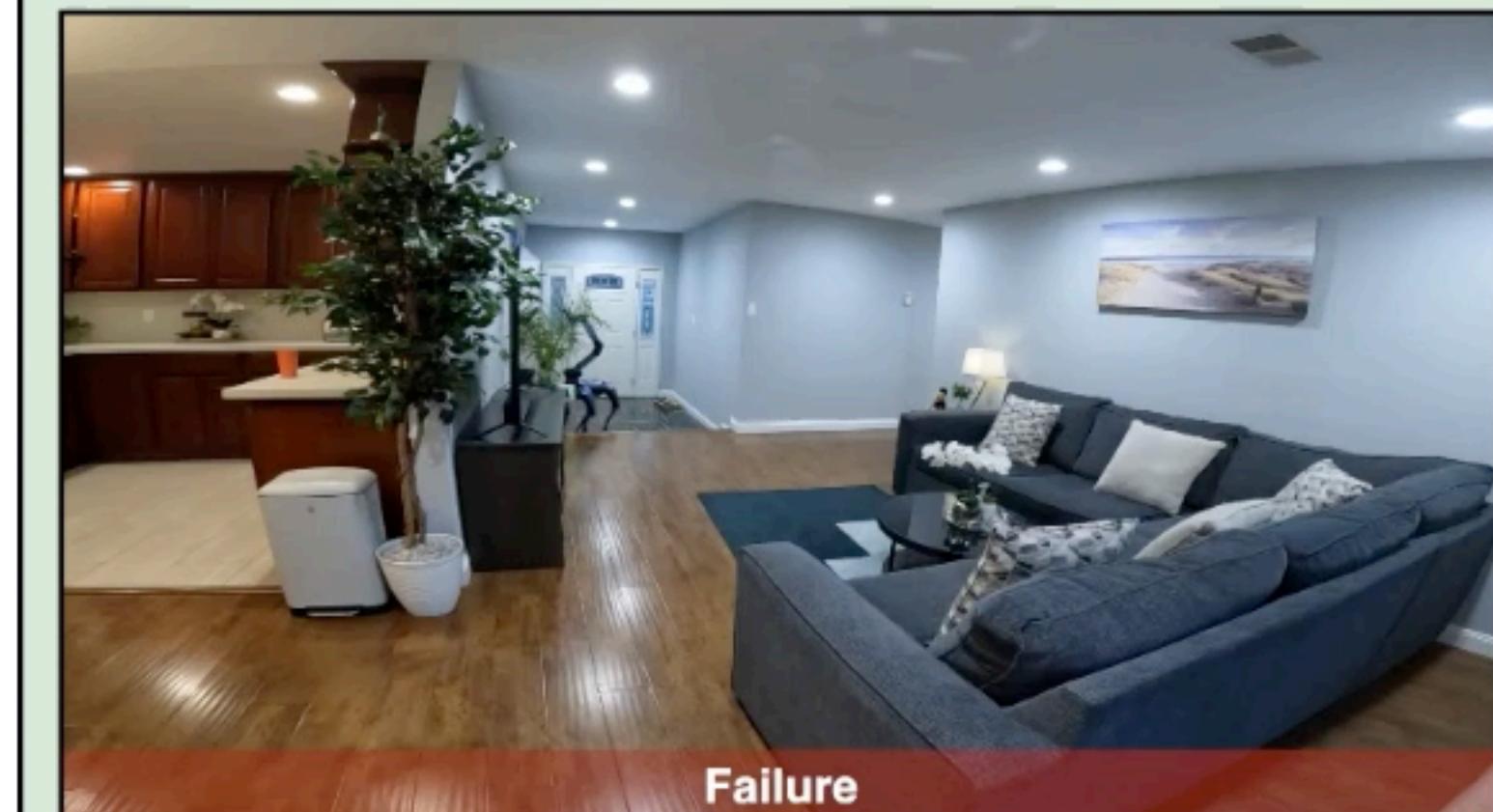


Observation

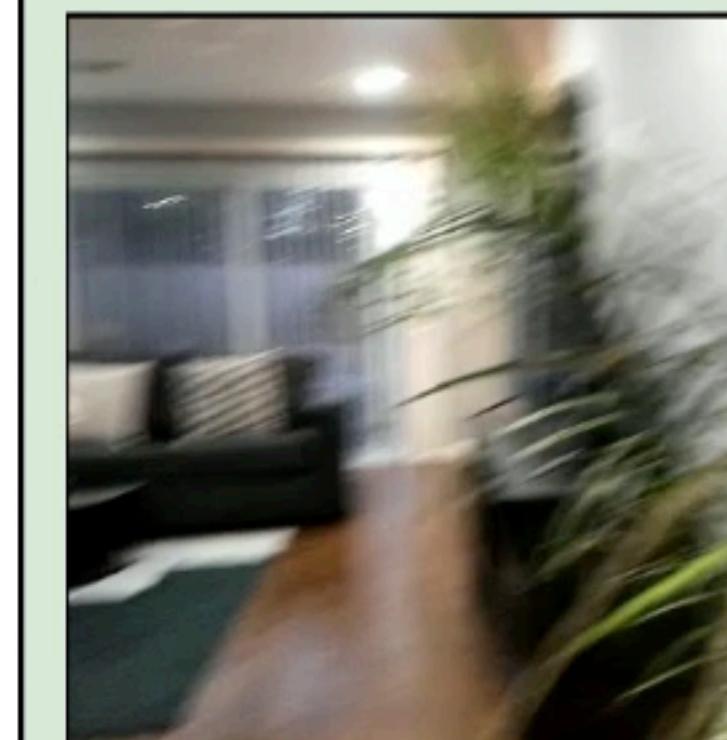


Instance Map

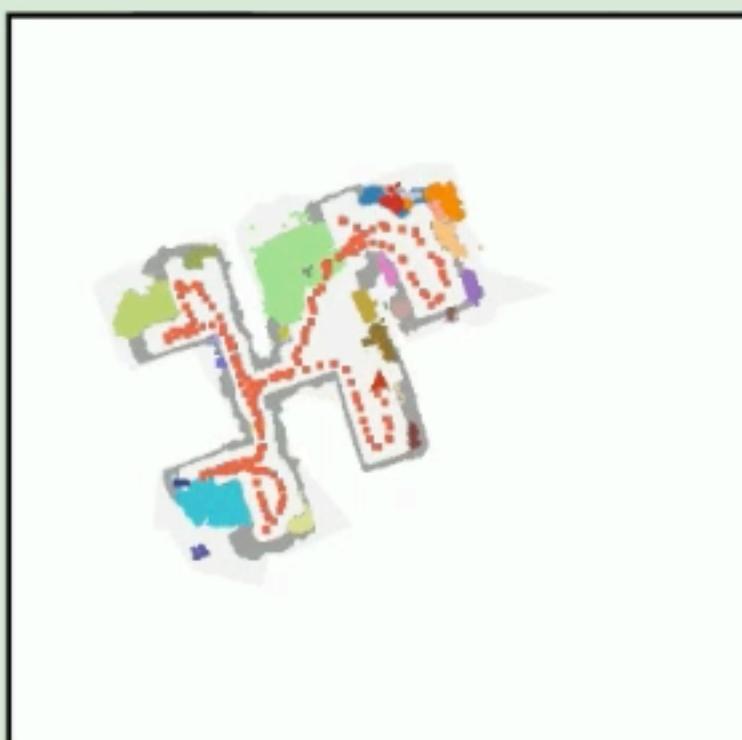
CoW



Failure



Observation



Instance Map

Success: 6/6 SPL: 0.78

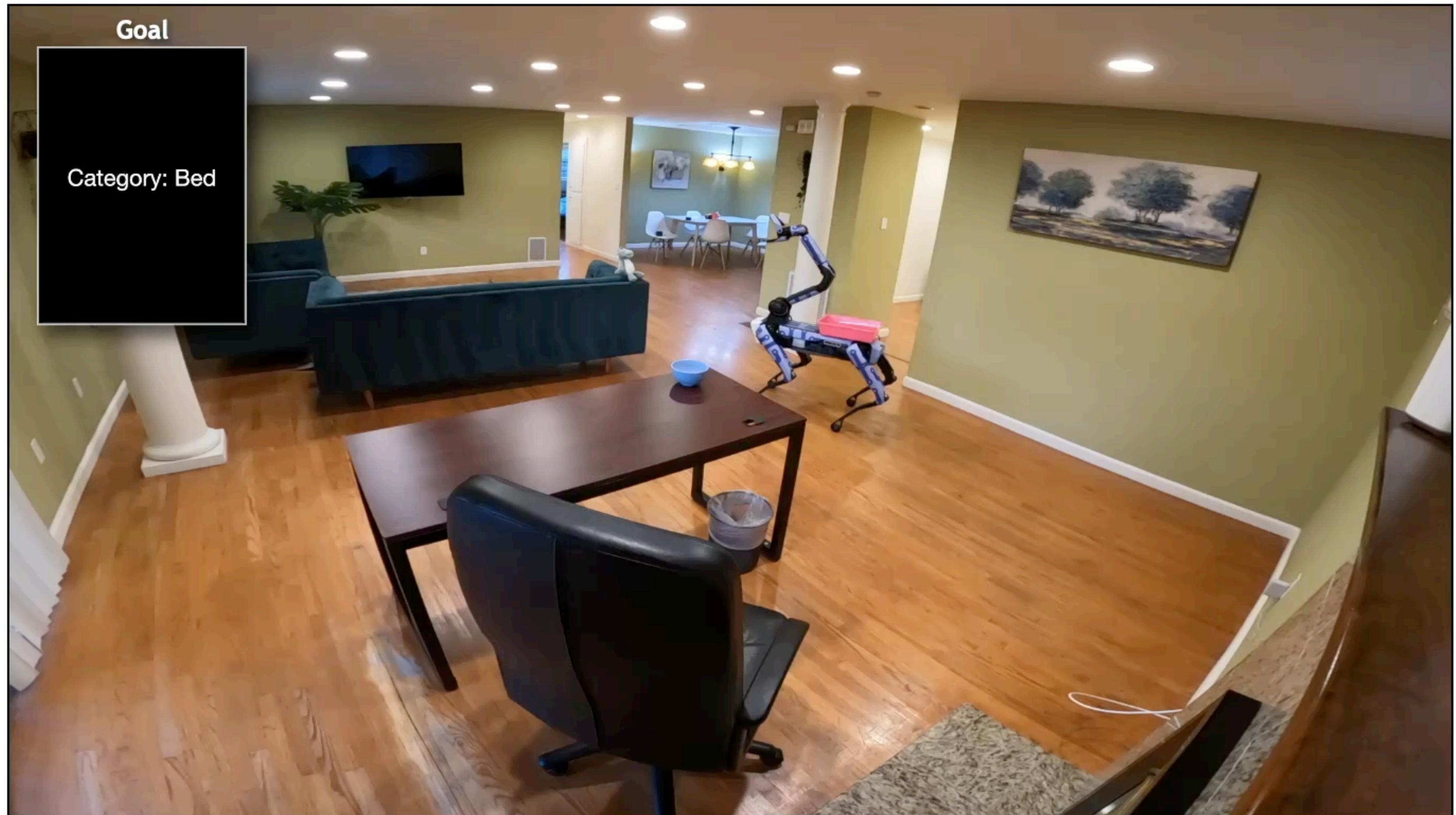
Success: 4/6 SPL: 0.40

Success: 1/6 SPL: 0.16

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# Pick & Place

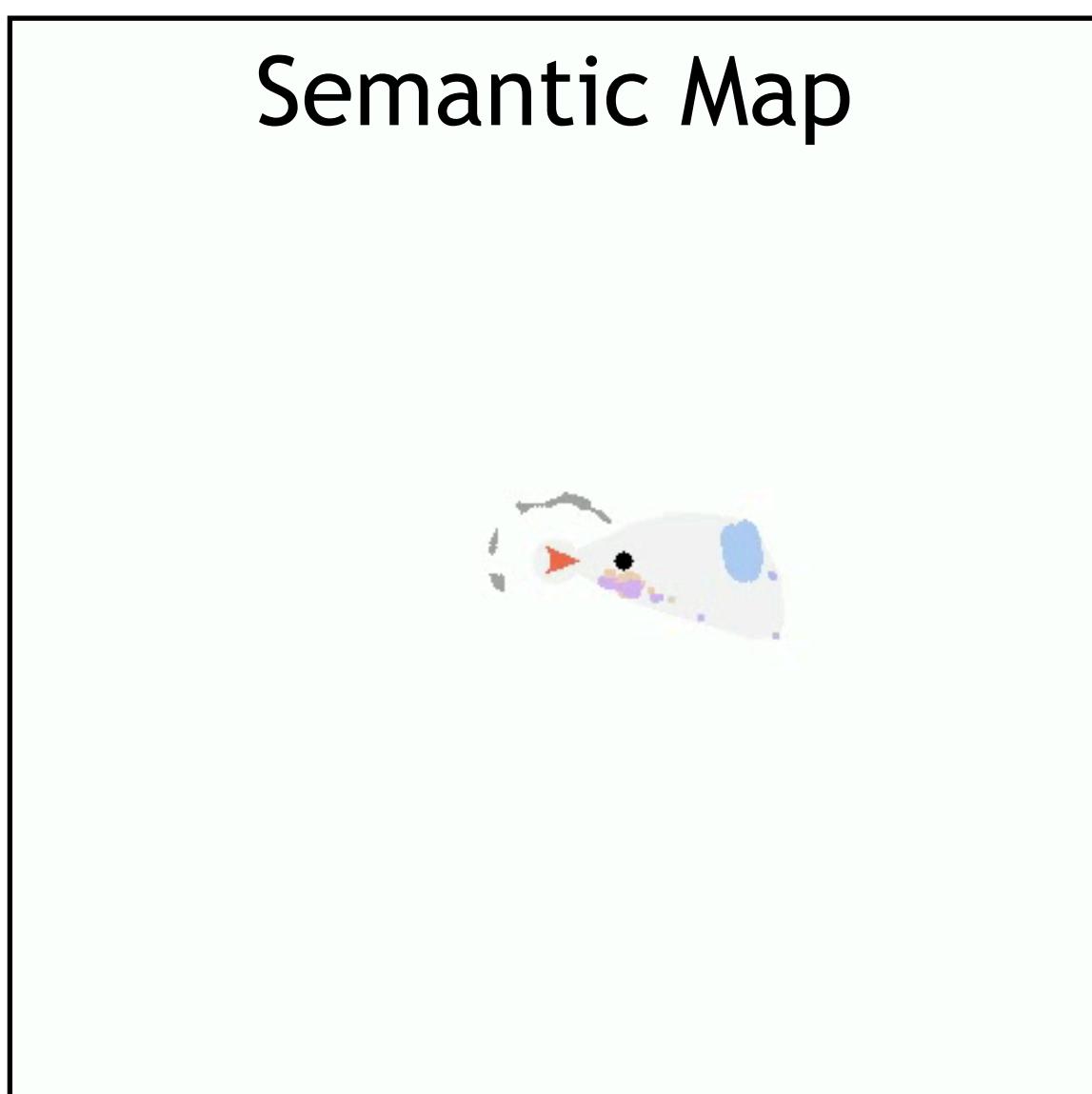
Third-person view



## Observation



## Semantic Map



## Third-person view



# Social Navigation

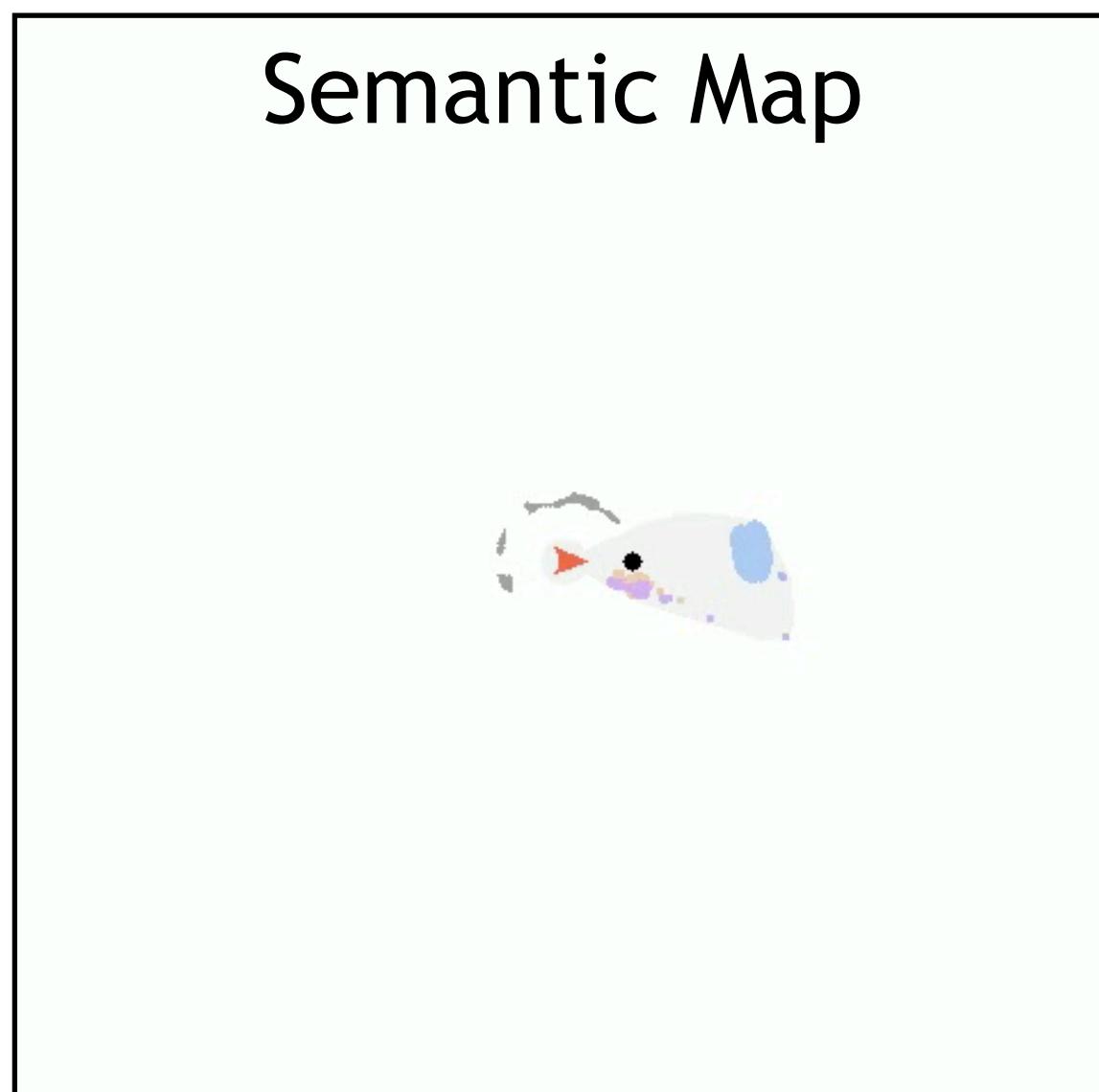
Observation



Third-person view



Semantic Map



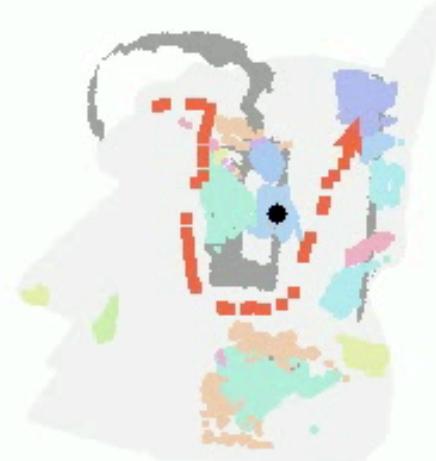
Robot plans around the dynamic obstacle (person) to go to the refrigerator

# Social Navigation

Observation



Semantic Map



Third-person view

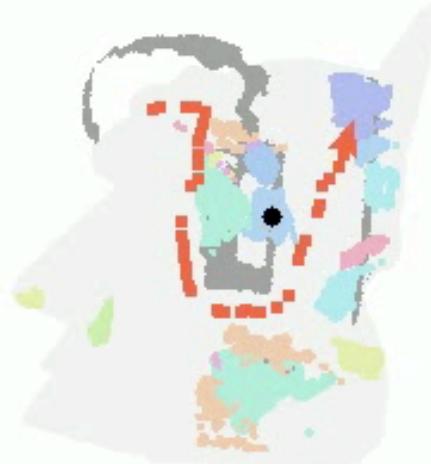


# Social Navigation

Observation



Semantic Map

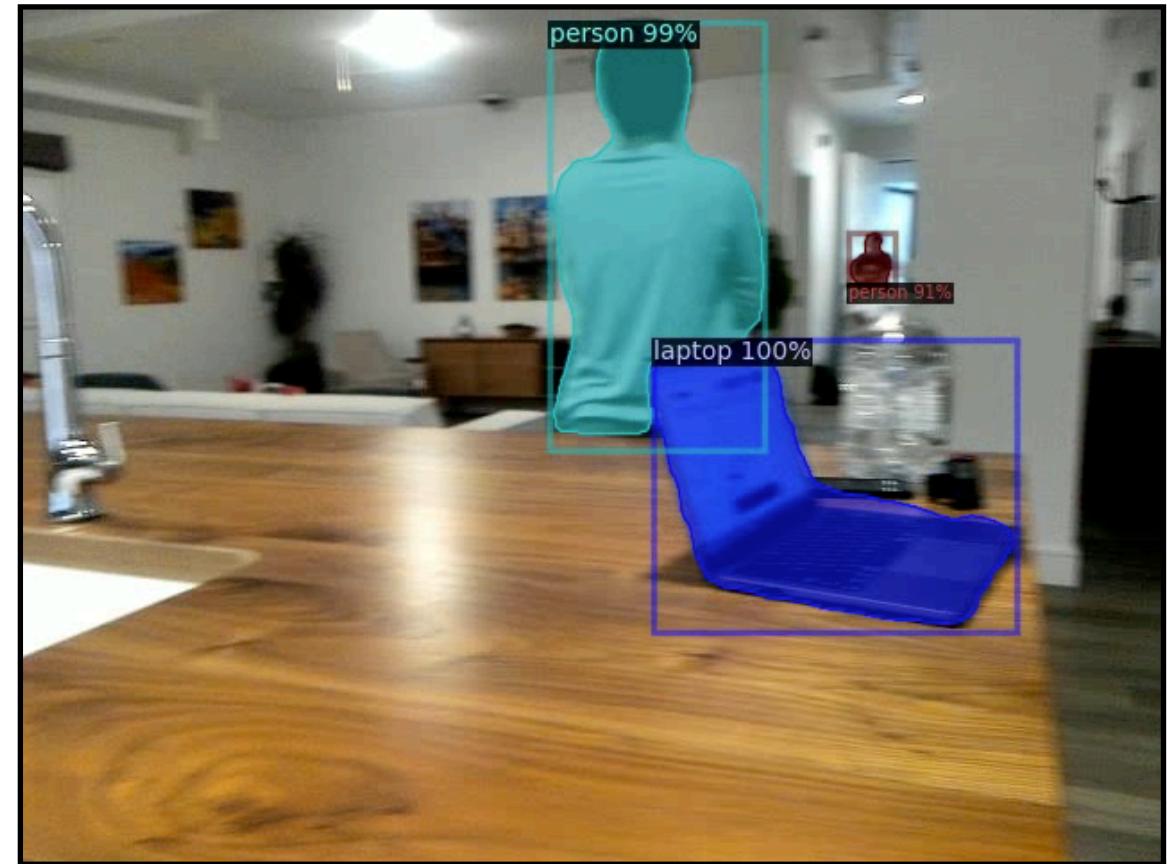


Third-person view



# Social Navigation

Observation



Semantic Map

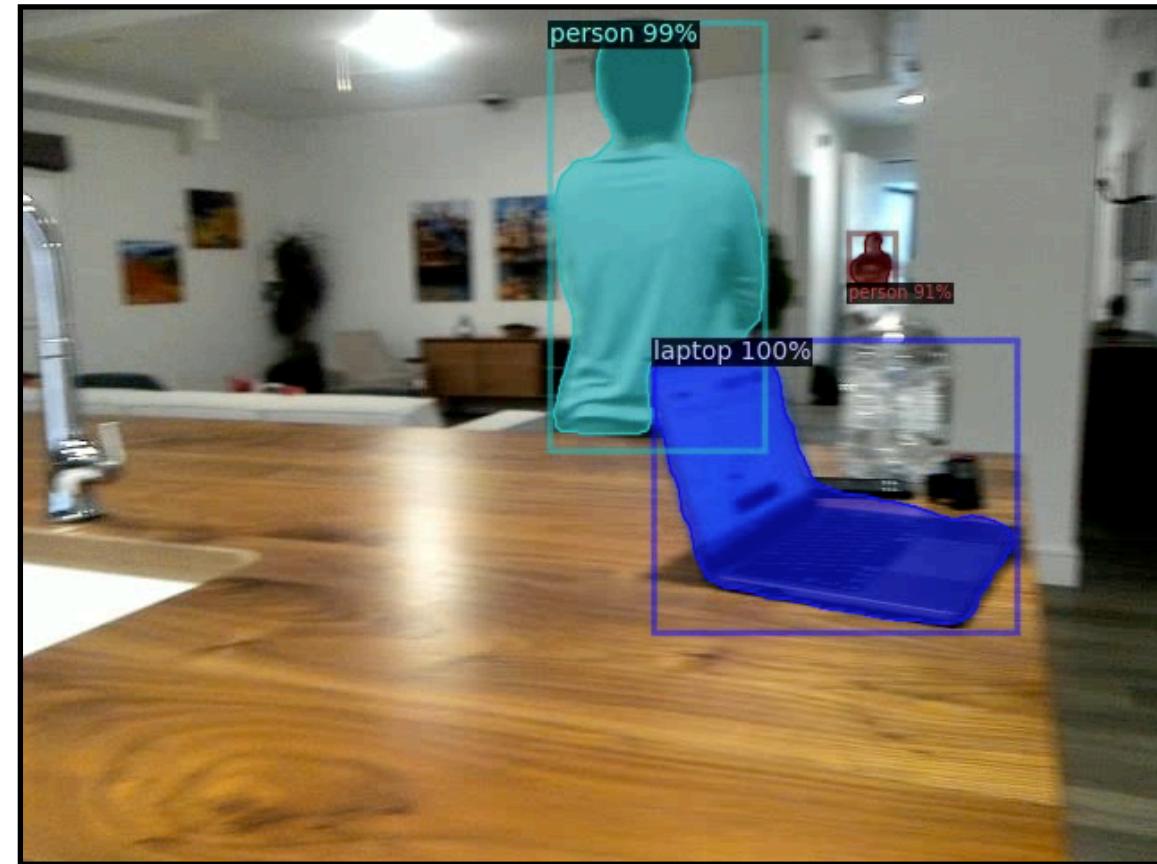


Third-person view

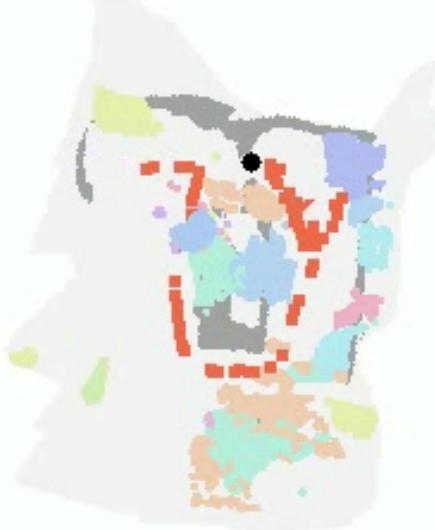


# Social Navigation

Observation



Semantic Map



Third-person view



Robot follows the person while updating their location

# Platform Agnostic

## Third-person view



# Summary

## Universal navigation

- Multimodal

Image



Language

*Find **the fruit basket on the kitchen counter***

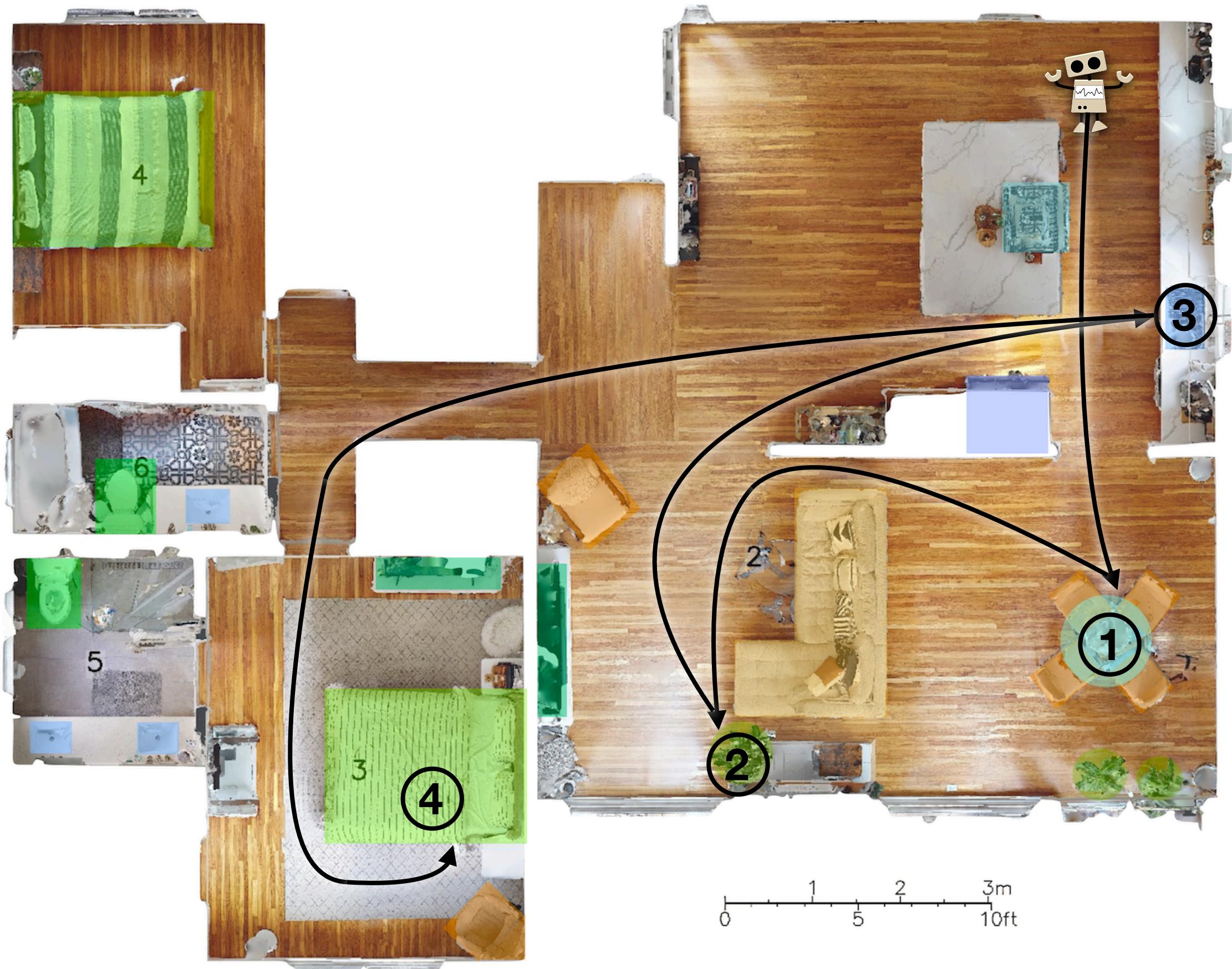
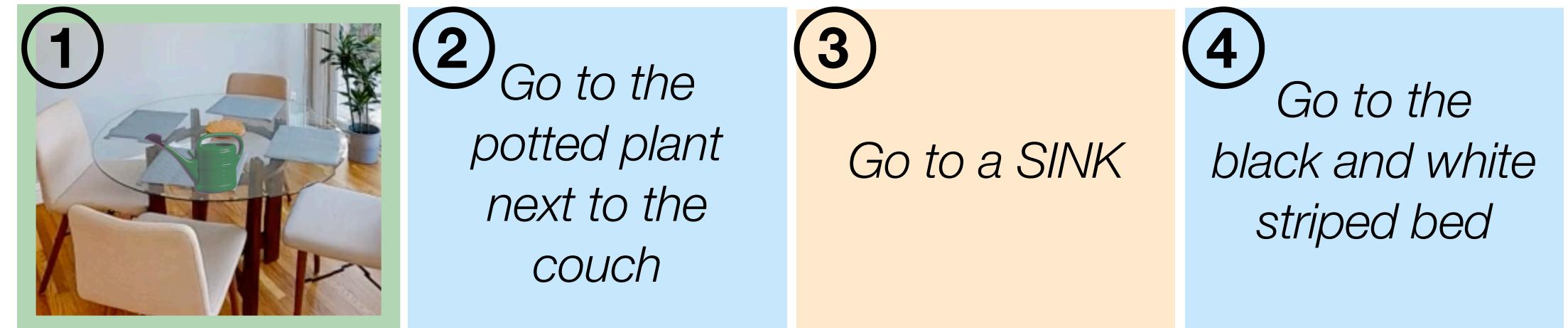
Category

*Bring me a CUP*

# Summary

## Universal navigation

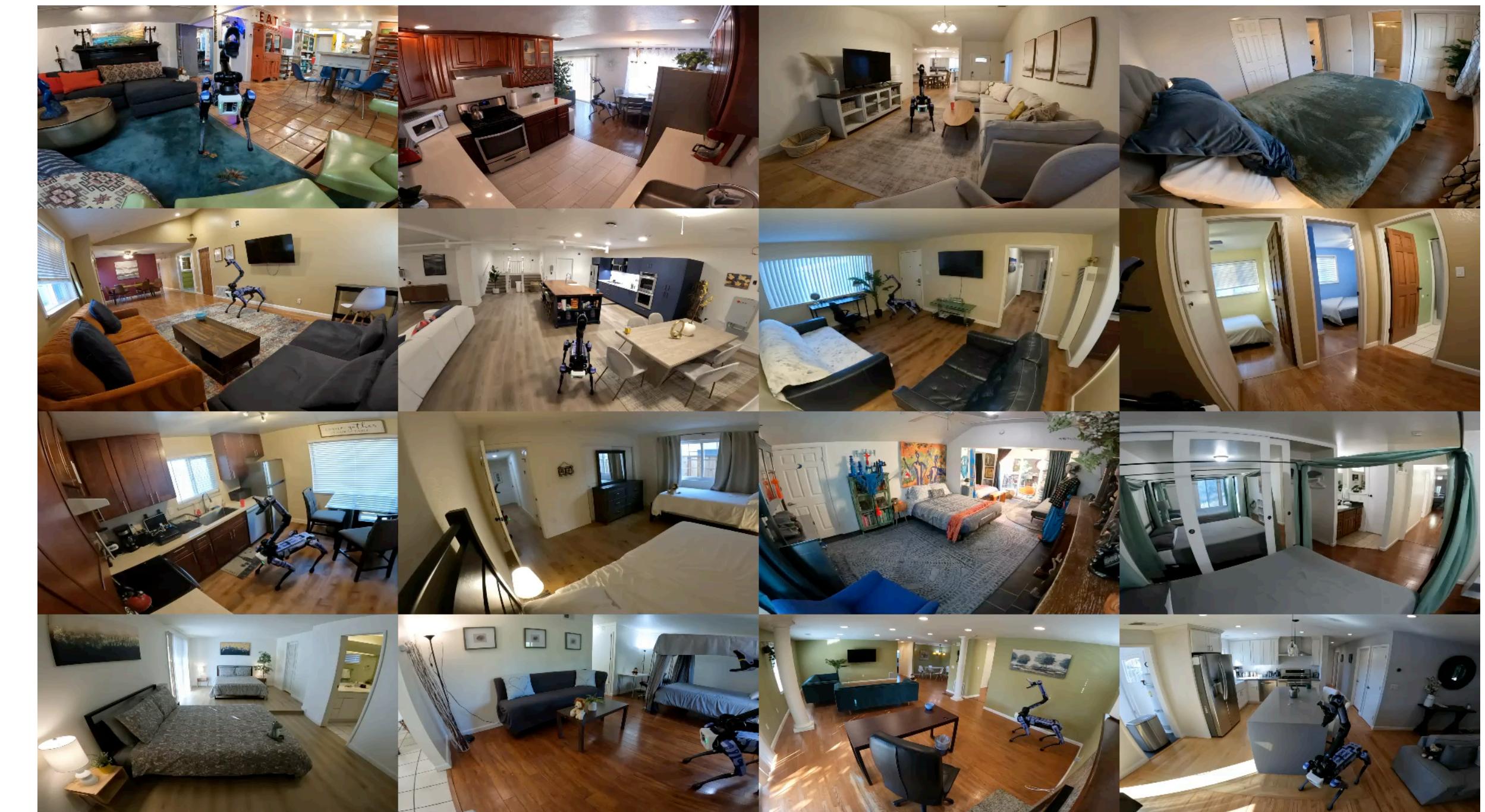
- Multimodal
- Lifelong



# Summary

## Universal navigation

- Multimodal
- Lifelong
- Unseen environments



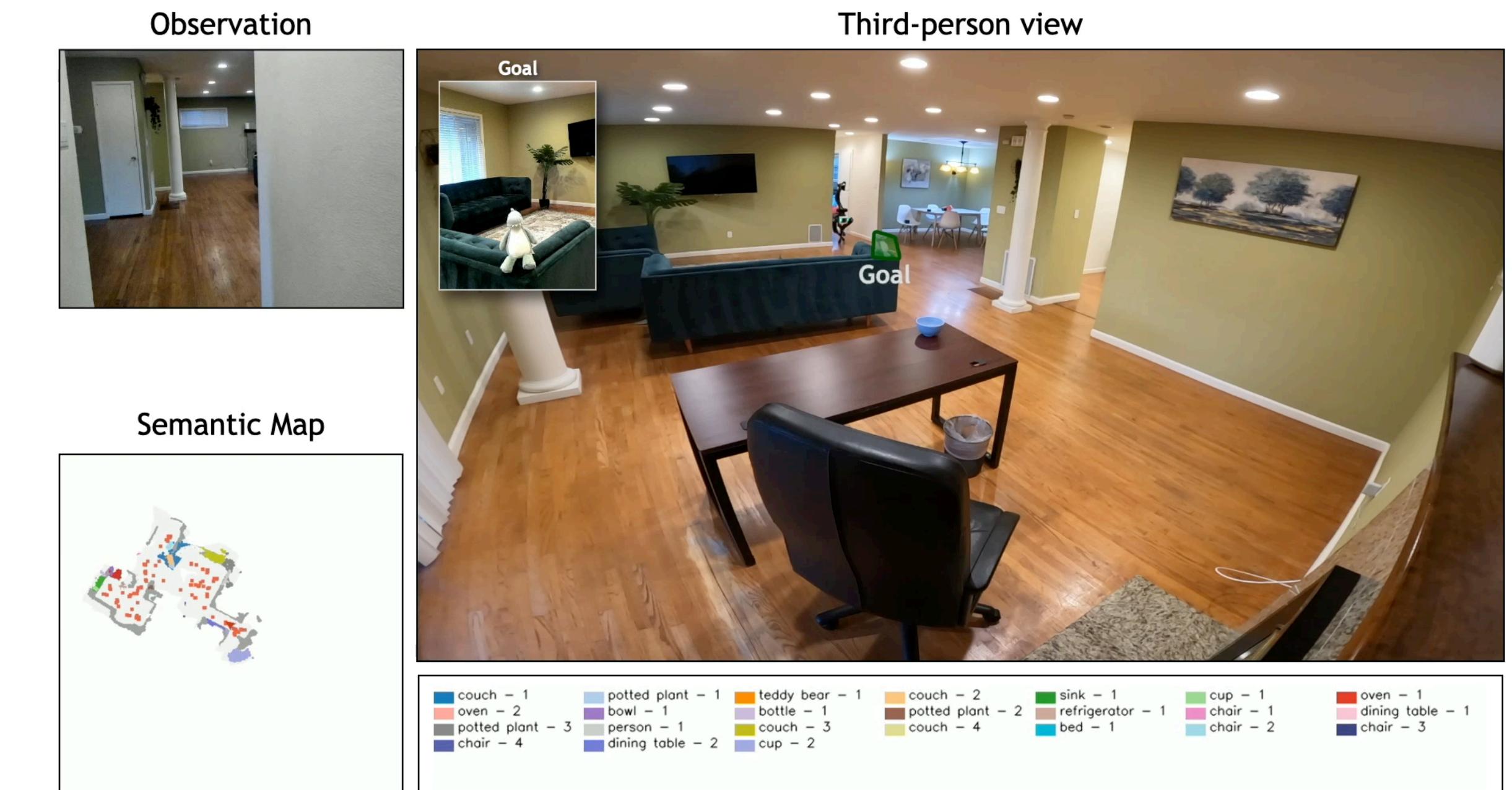
# Summary

## Universal navigation

- Multimodal
- Lifelong
- Unseen environments

## Applications

- Pick & Place



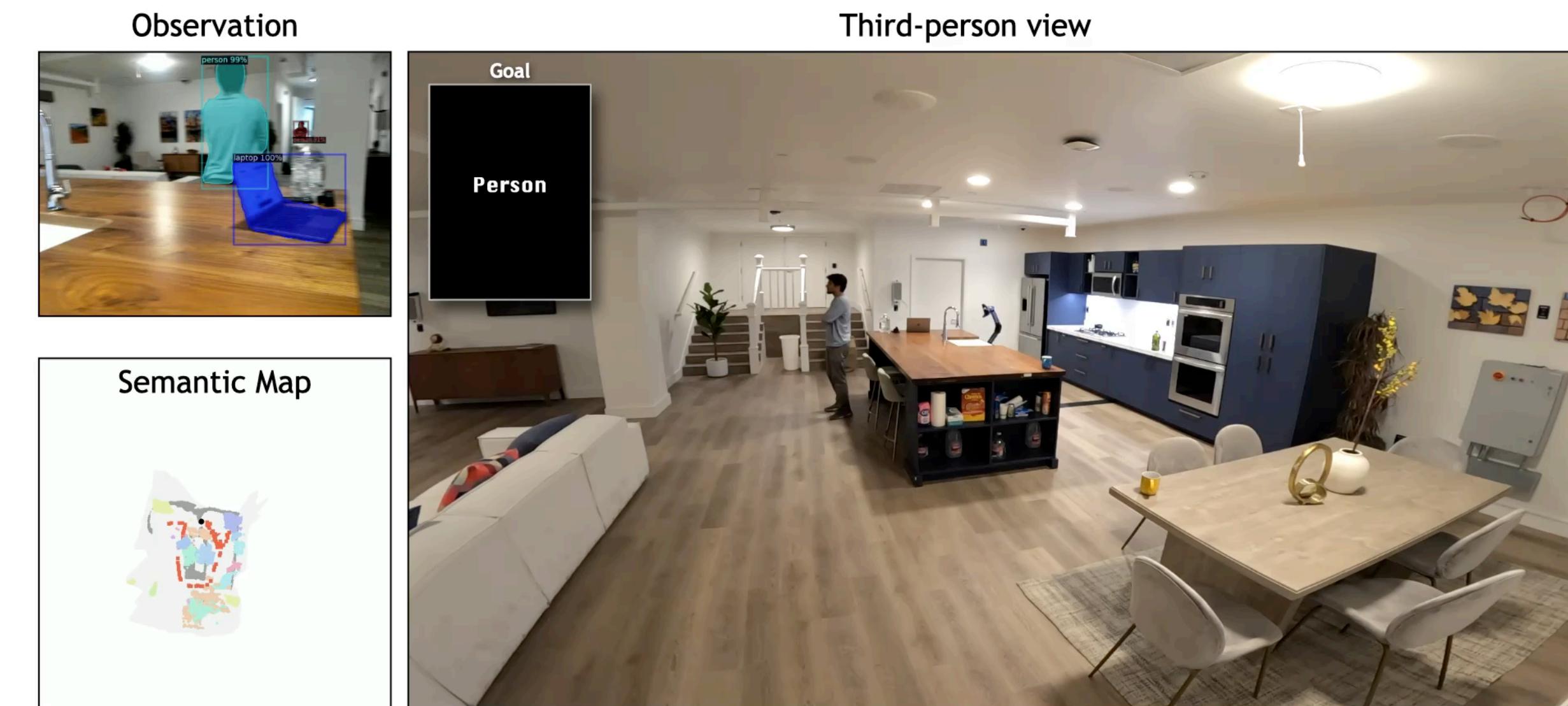
# Summary

## Universal navigation

- Multimodal
- Lifelong
- Unseen environments

## Applications

- Pick & Place
- Social Navigation



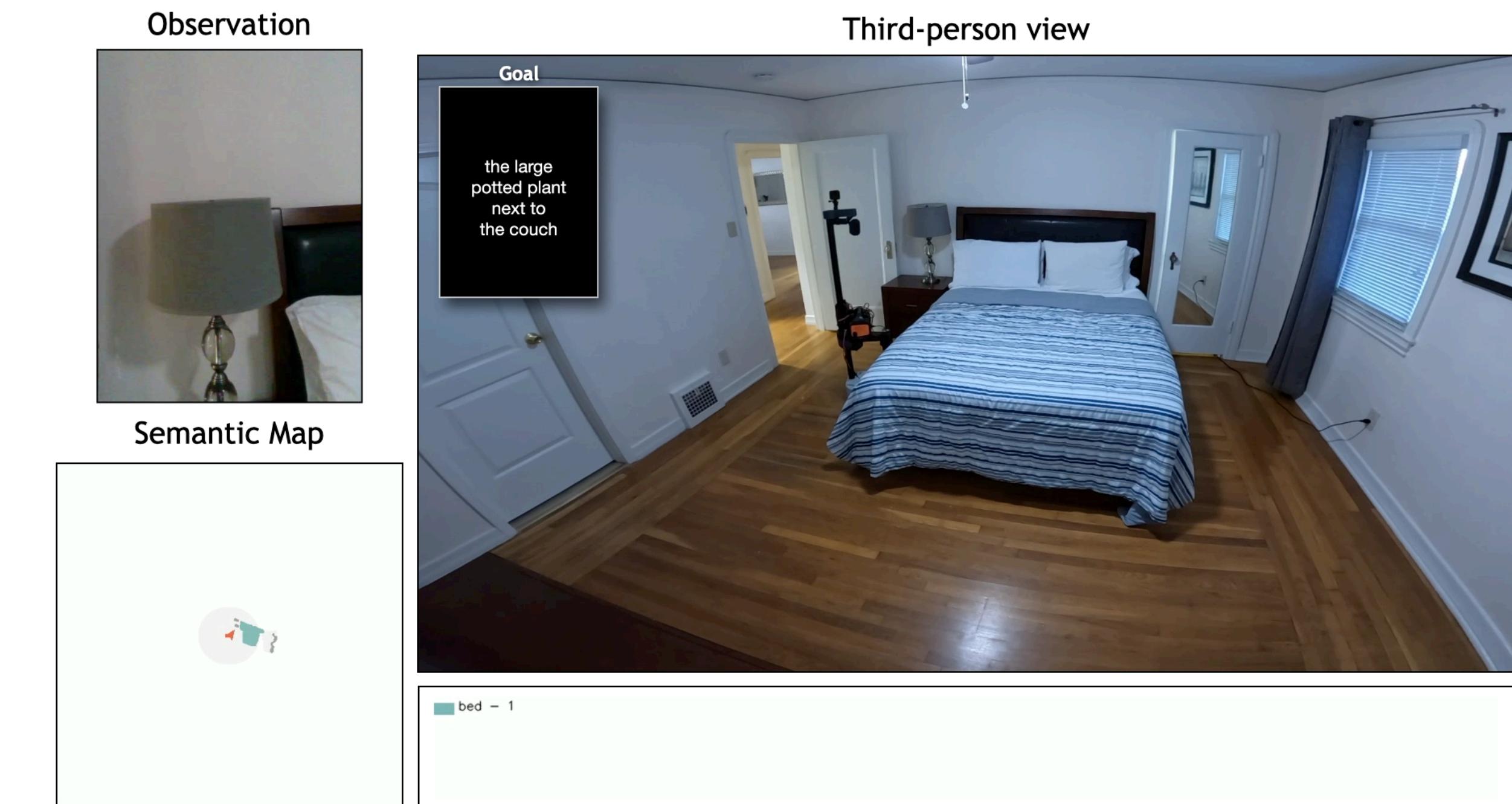
# Summary

## Universal navigation

- Multimodal
- Lifelong
- Unseen environments

## Applications

- Pick & Place
- Social Navigation
- Platform Agnostic





Thank you!

Webpage: <https://theophilegervet.github.io/projects/goat>