

# **Creación y Aprovechamiento de Mapas Semánticos en Robótica Empleando Modelos de Gran Escala**

**Building and Exploiting Semantic Maps in Robotics Using Large  
Models**

Realizado por:

**Jesús Moncada Ramírez**

Tutorizado por:

**Antonio Javier González Jiménez**

**José Raúl Ruiz Sarmiento**

**Grado en Ingeniería Informática**

Málaga, julio de 2024



UNIVERSIDAD DE MÁLAGA

# 1

# Introduction

# Motivation -----

## 1. Introduction

Robots are increasingly being deployed in diverse applications...



Metric maps

Topological maps

Hybrid maps

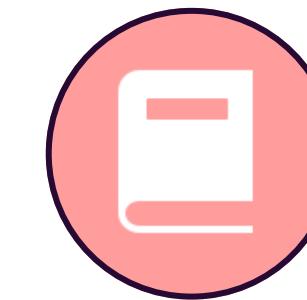
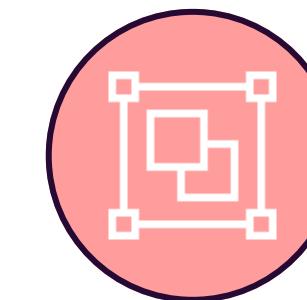
Need:  
COGNITIVE CAPABILITIES

# Semantic Maps

# Motivation

## 1. Introduction

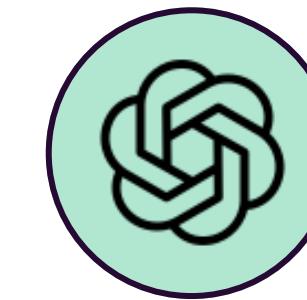
**TRADITIONAL  
SEMANTIC  
MAPS**



Object  
detector

Knowledge  
base

**SOLUTION**  
based on ConceptGraphs



**Large Models**

Large Language Models  
(LLMs)

Large Vision-Language  
Models (LVLMs)

**Closed  
vocabulary**

**Closed  
knowledge base**

**Open**

set of categories

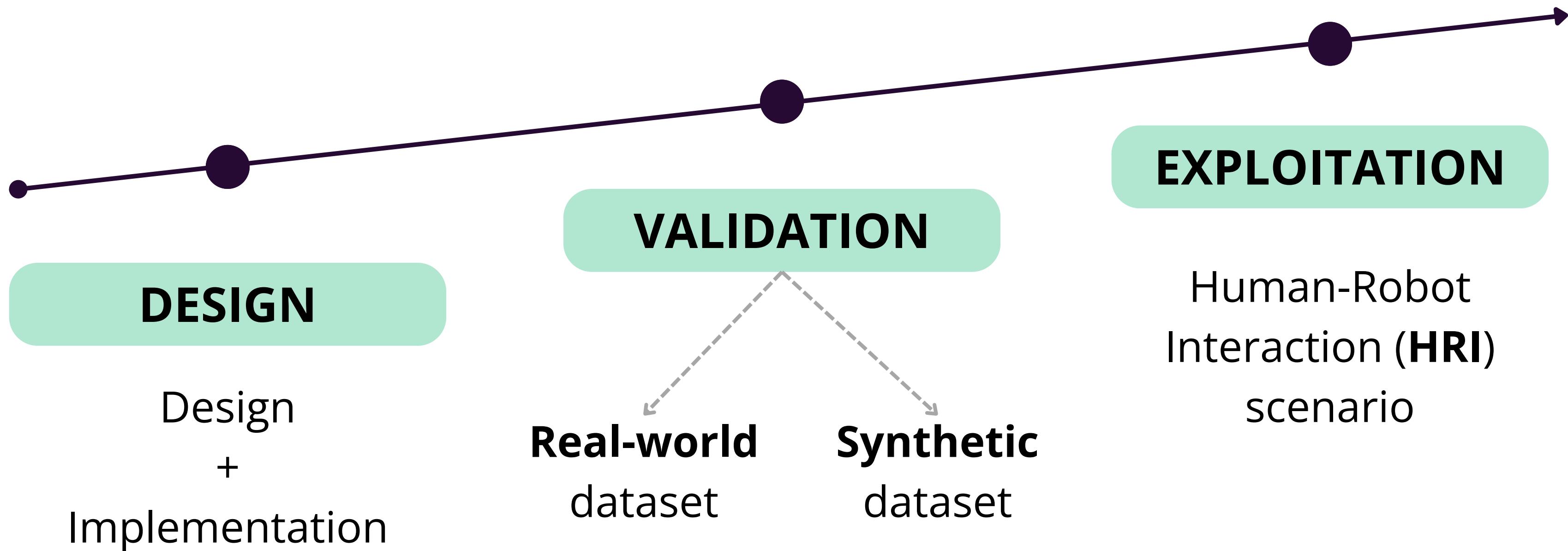
**Open**

knowledge base

# Objectives

## 1. Introduction

A semantic mapping method...



# Jornadas de Automática ----- 1. Introduction



## Jornadas de Automática

Modelos a gran escala para mapeo semántico en robótica móvil

Moncada-Ramirez, J.\*., Ruiz-Sarmiento, J.R., Matez-Bandera, J.L., Gonzalez-Jimenez, J.

Grupo de Percepción Artificial y Robótica Inteligente (MAPIR), Dept. de Ingeniería de Sistemas y Automática, Instituto Universitario en Ingeniería Mecatrónica y Sistemas Ciberfísicos (IMECH.UMA), Universidad de Málaga, Blvr. Louis Pasteur, 35, 29071 Málaga, España.

**To cite this article:** Moncada-Ramirez, J., Ruiz-Sarmiento, J.R., Matez-Bandera, J.L., Gonzalez-Jimenez, J. 2024.

Large models for semantic mapping in mobile robotics.

Jornadas de Automática, 45. <https://doi.org/>

### Resumen

La aparición de los modelos a gran escala permite abordar algunas de las principales limitaciones que presentan las técnicas de mapeo semántico tradicional en robótica móvil. Sin embargo, estos modelos son propensos a generar respuestas incorrectas, incoherentes o incluso inventadas, pudiendo ocasionar comportamientos erróneos del robot. Para poder desplegarse en aplicaciones reales, por tanto, es crucial desarrollar mecanismos que permitan mitigar estas errores. En este trabajo se utiliza *ConceptGraphs*, un método del estado del arte basado en modelos a gran escala para construir mapas semánticos, sobre el que se plantean dos estrategias para reducir las respuestas erróneas. Primero, se propone adaptar el método para operar con modelos más recientes (por ejemplo, Gemini 1.5 y ChatGPT-4o). En segundo lugar, se incorpora una etapa de refinamiento de respuestas mediante la técnica denominada *Reflexión*, que permite al modelo autoevaluar y mejorar sus propias respuestas. Finalmente, se validan las propuestas mediante experimentos en entornos reales del conjunto de datos ScanNet.

**Palabras clave:** Robótica inteligente, Aprendizaje automático, Robots móviles autónomos, Construcción de mapas, Percepción y sensado

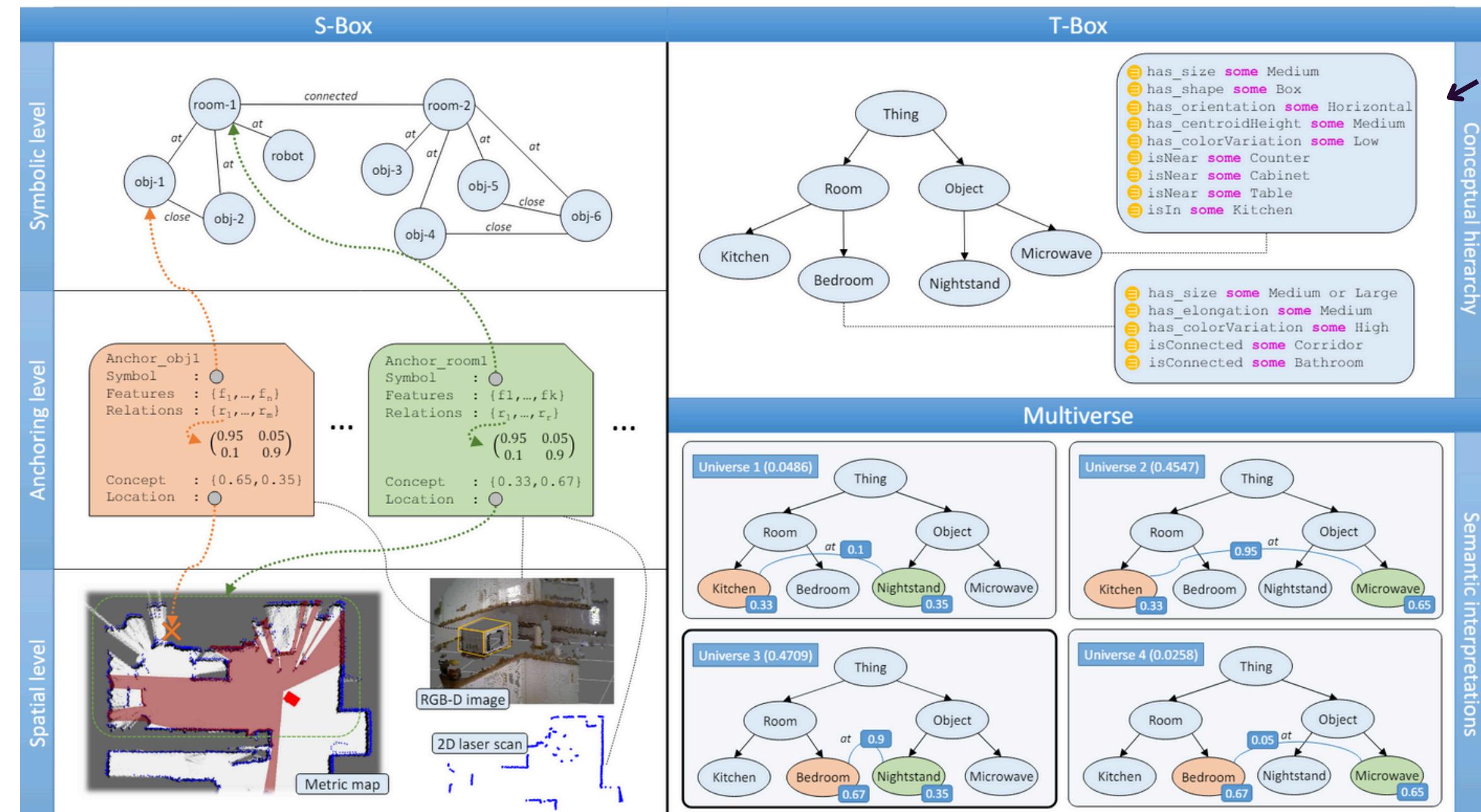
2

# Background

# Semantic maps

## 2. Background

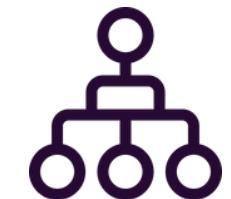
-  Factual information
-  Geometric information



Semantic information



Ontologies



Hierarchical information

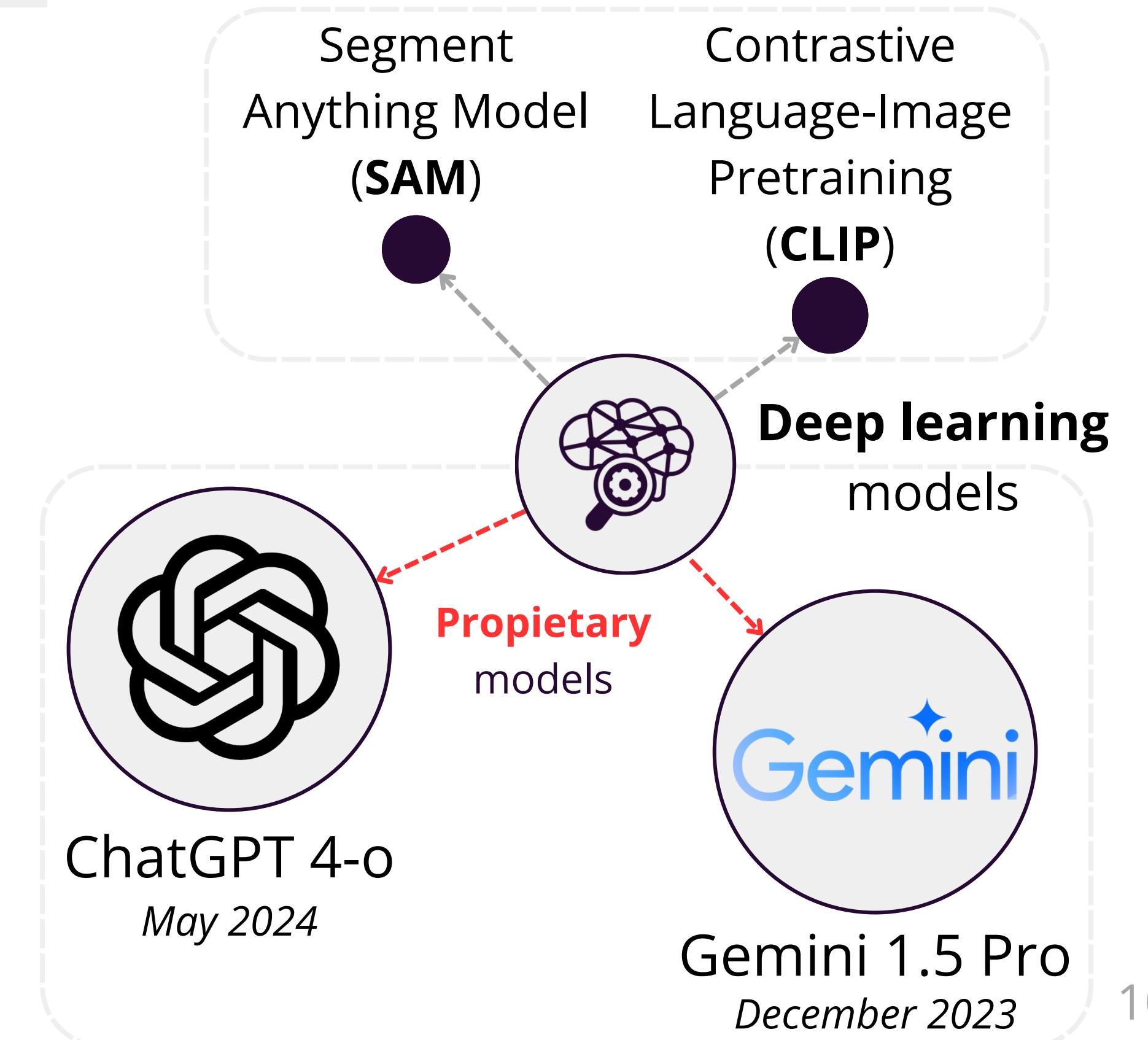
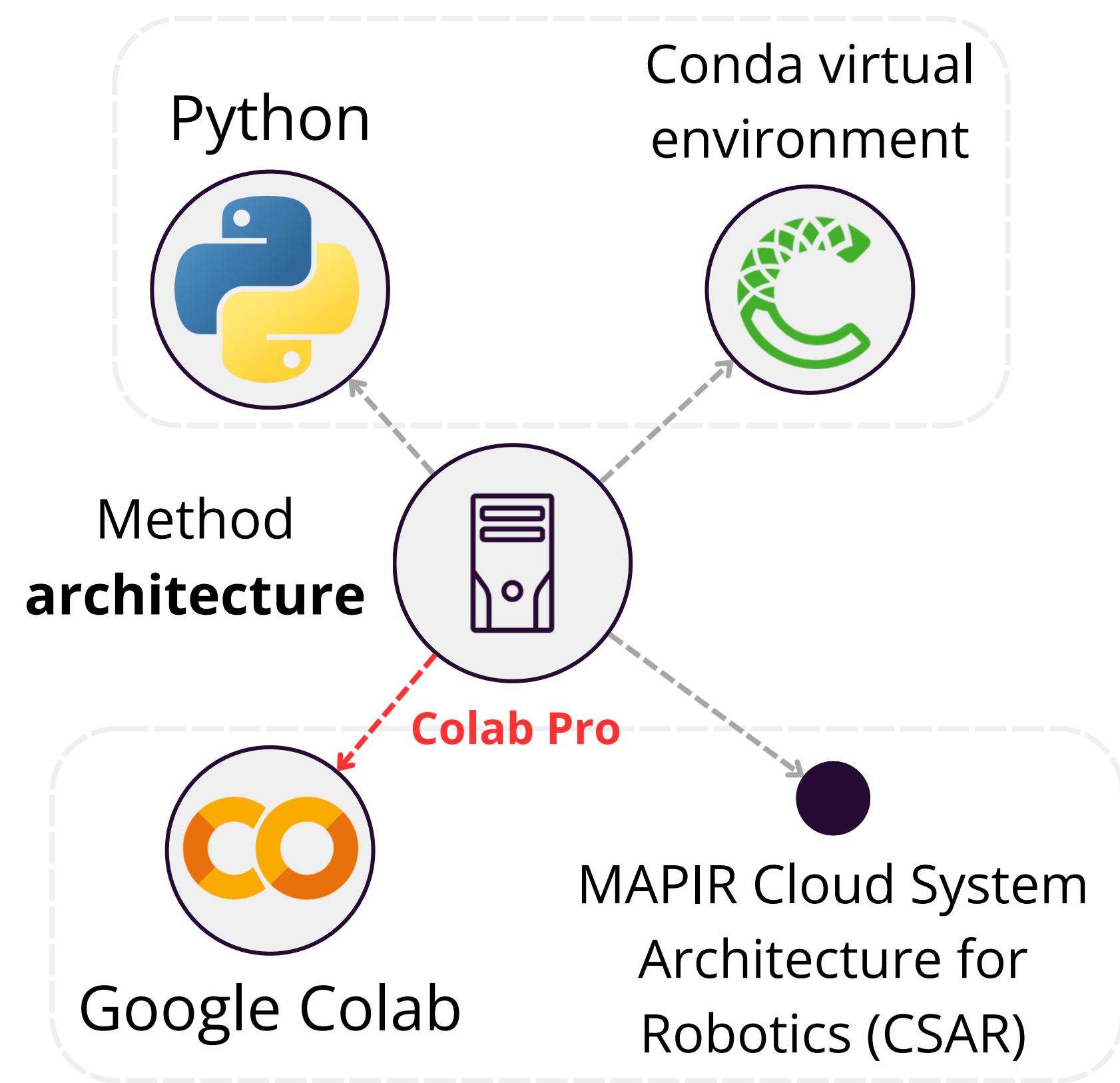
Example of a Multiversal Semantic Map (2017)

# 3

# Used technologies

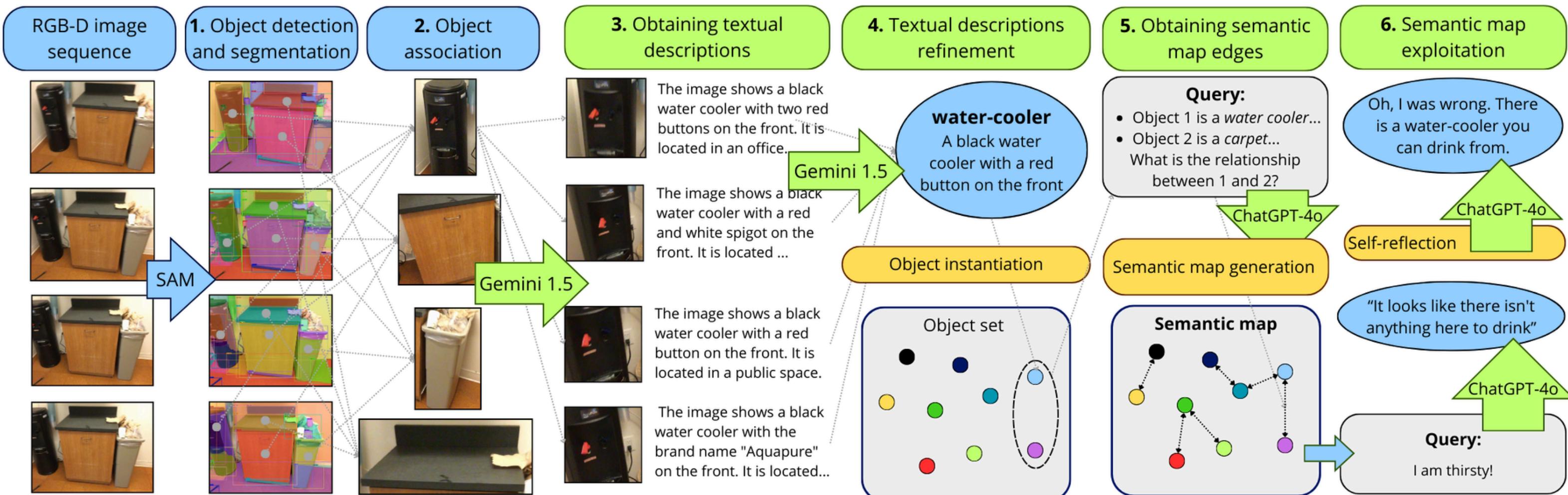
# Used technologies

## 3. Used technologies



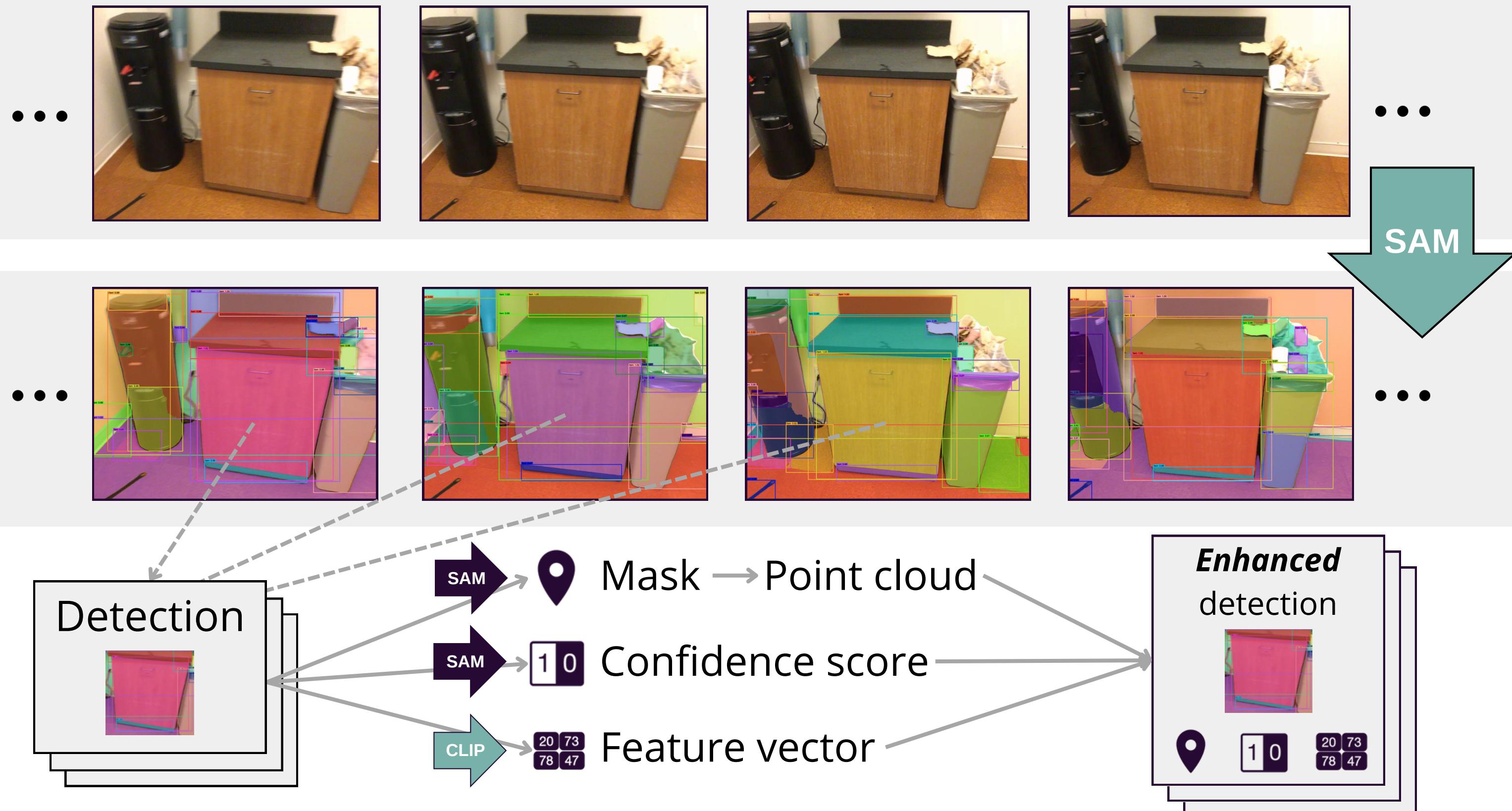
# 4

# Semantic mapping method



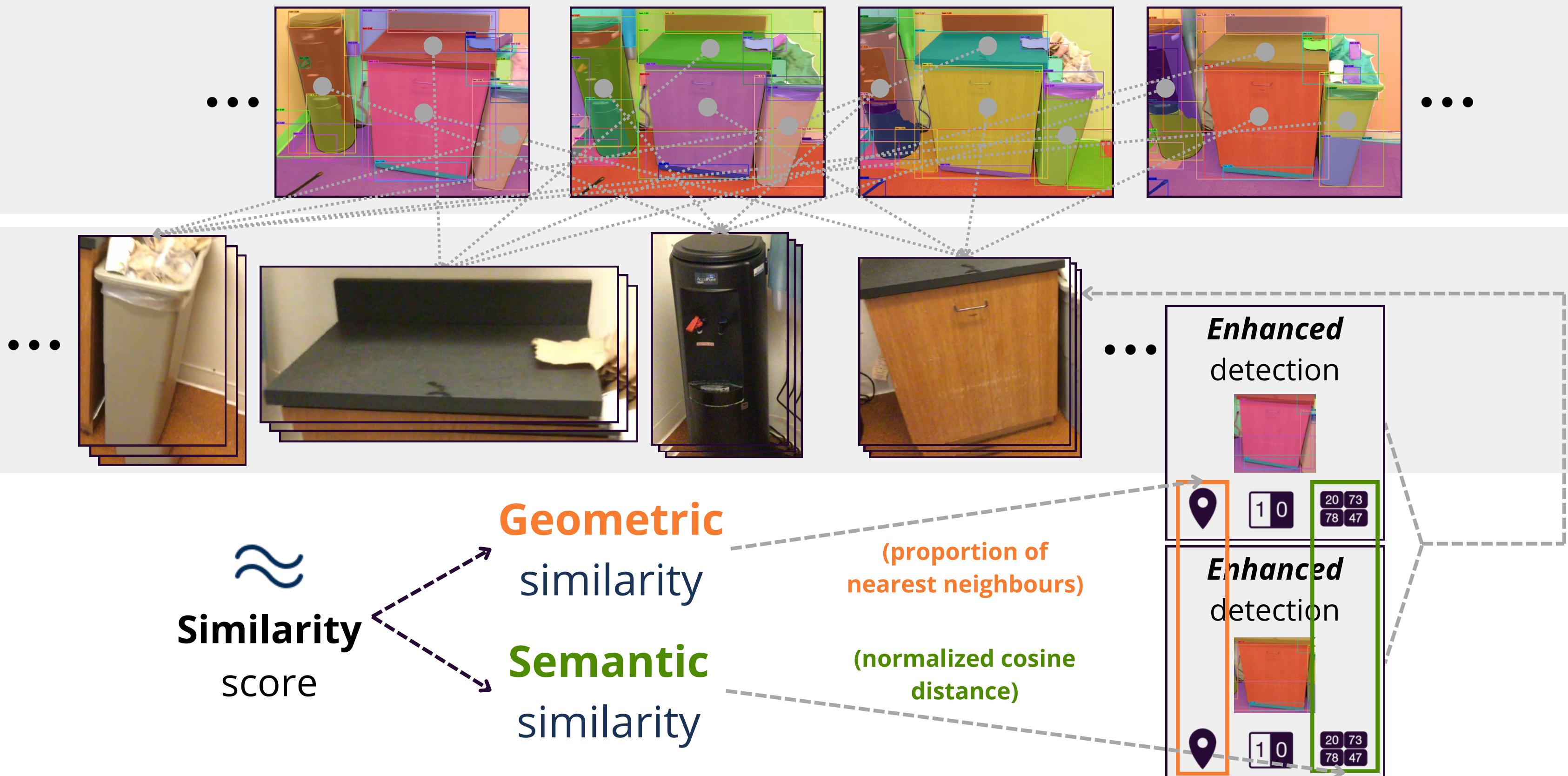
# Object detection

## 4. Semantic mapping method



# Object association

## 4. Semantic mapping method



# Object textual descriptions

## 4. Semantic mapping method

Visual  
detections



Textual  
descriptions

The image shows a black water cooler with two red buttons on the front. It is located in an office.

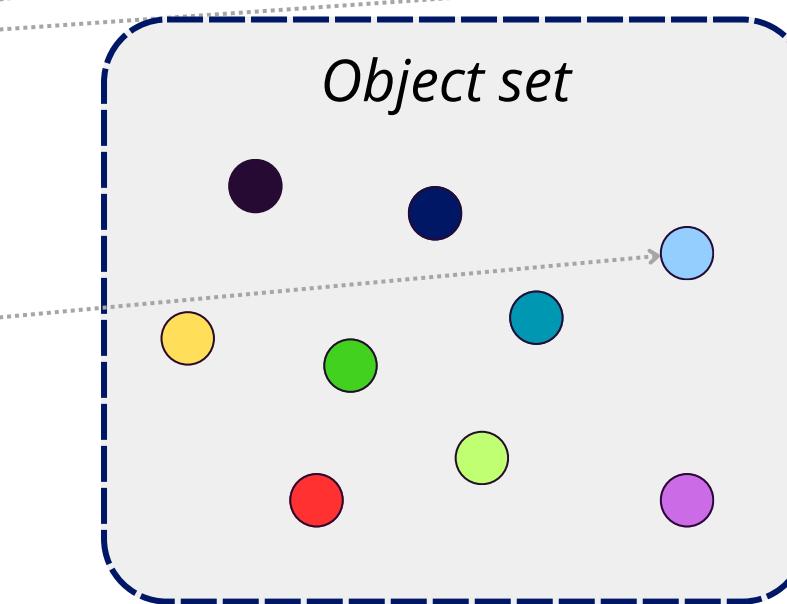
The image shows a black water cooler with a red and white spigot on the front. It is located ...

The image shows a black water cooler with a red button on the front. It is located in a public space.

The image shows a black water cooler with the brand name "Aquasure" on the front. It is located...

<language tag>  
<textual description>

**water-cooler**  
A black water cooler with a red button on the front

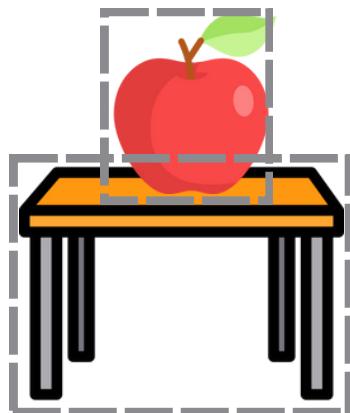
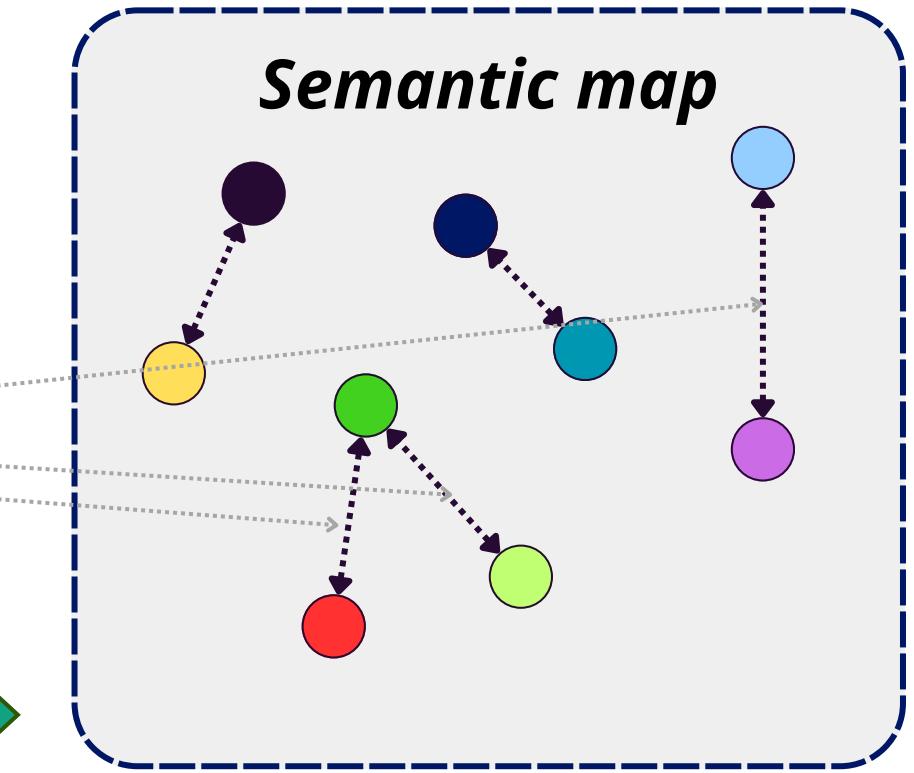
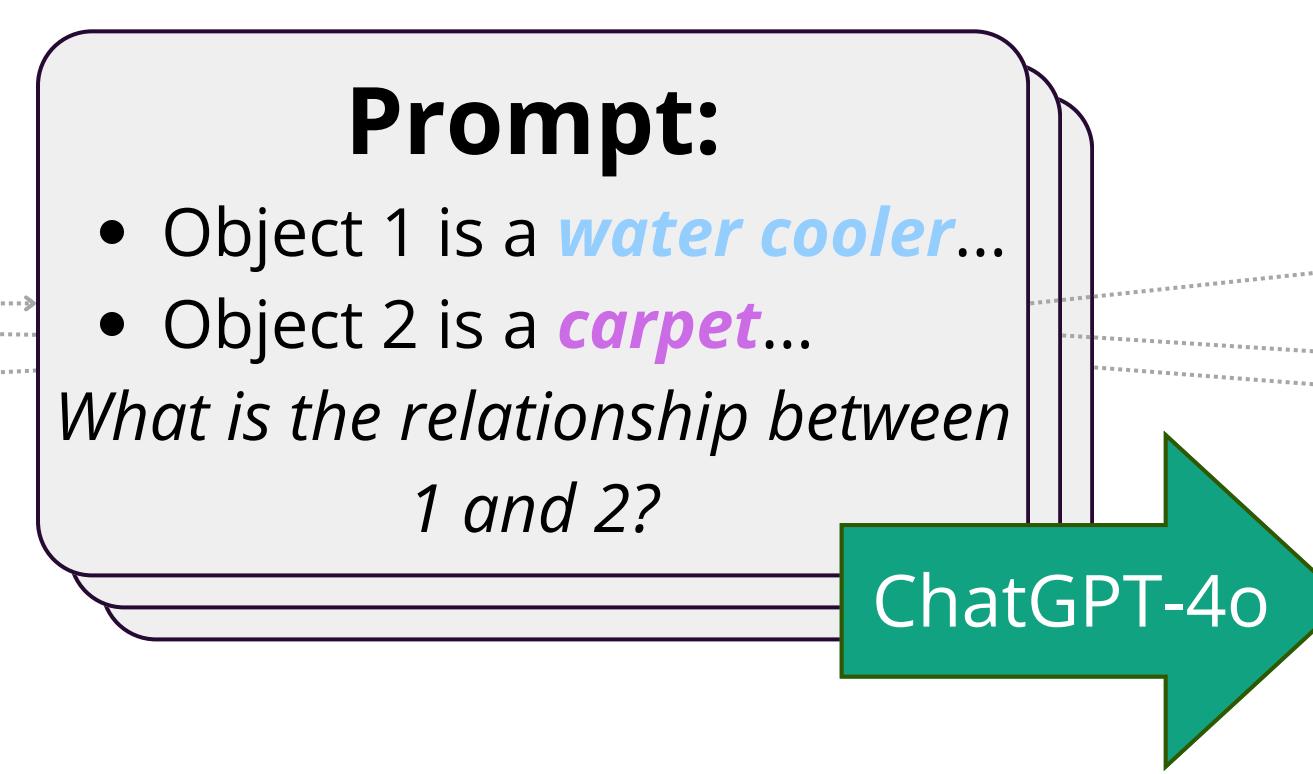
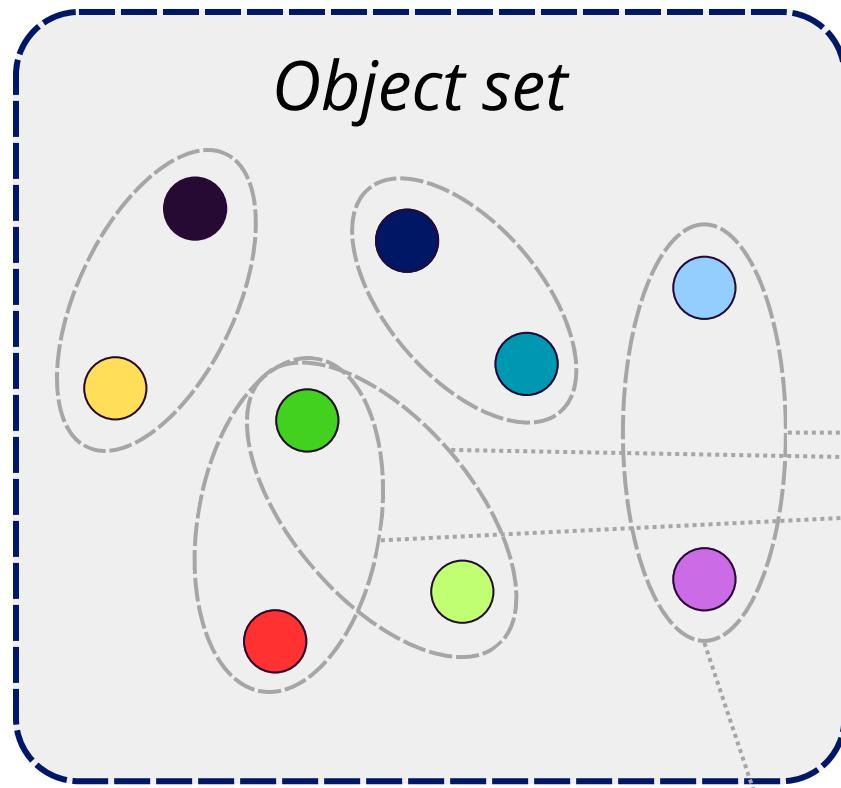


Gemini  
1.5 Pro

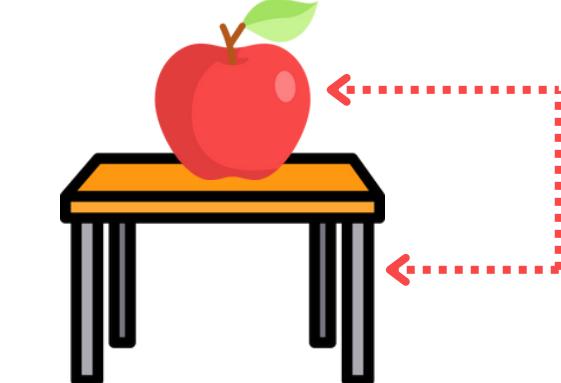
Gemini  
1.5 Pro

# Semantic map generation

## 4. Semantic mapping method



**Overlapping  
bounding boxes**



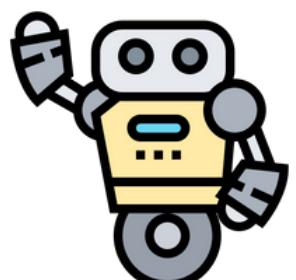
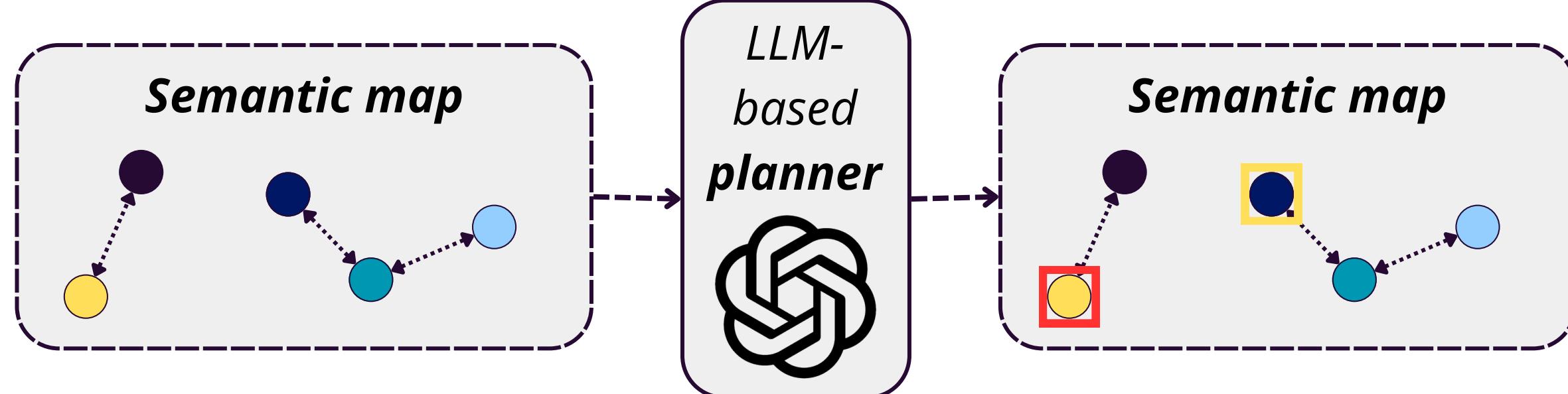
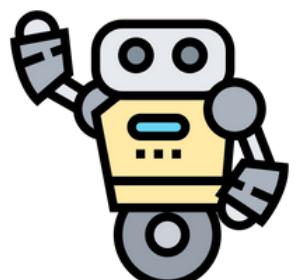
**Apple  
on  
table**

# Semantic map exploitation

## 4. Semantic mapping method



Hey I would like to <*action*>, could you help me?

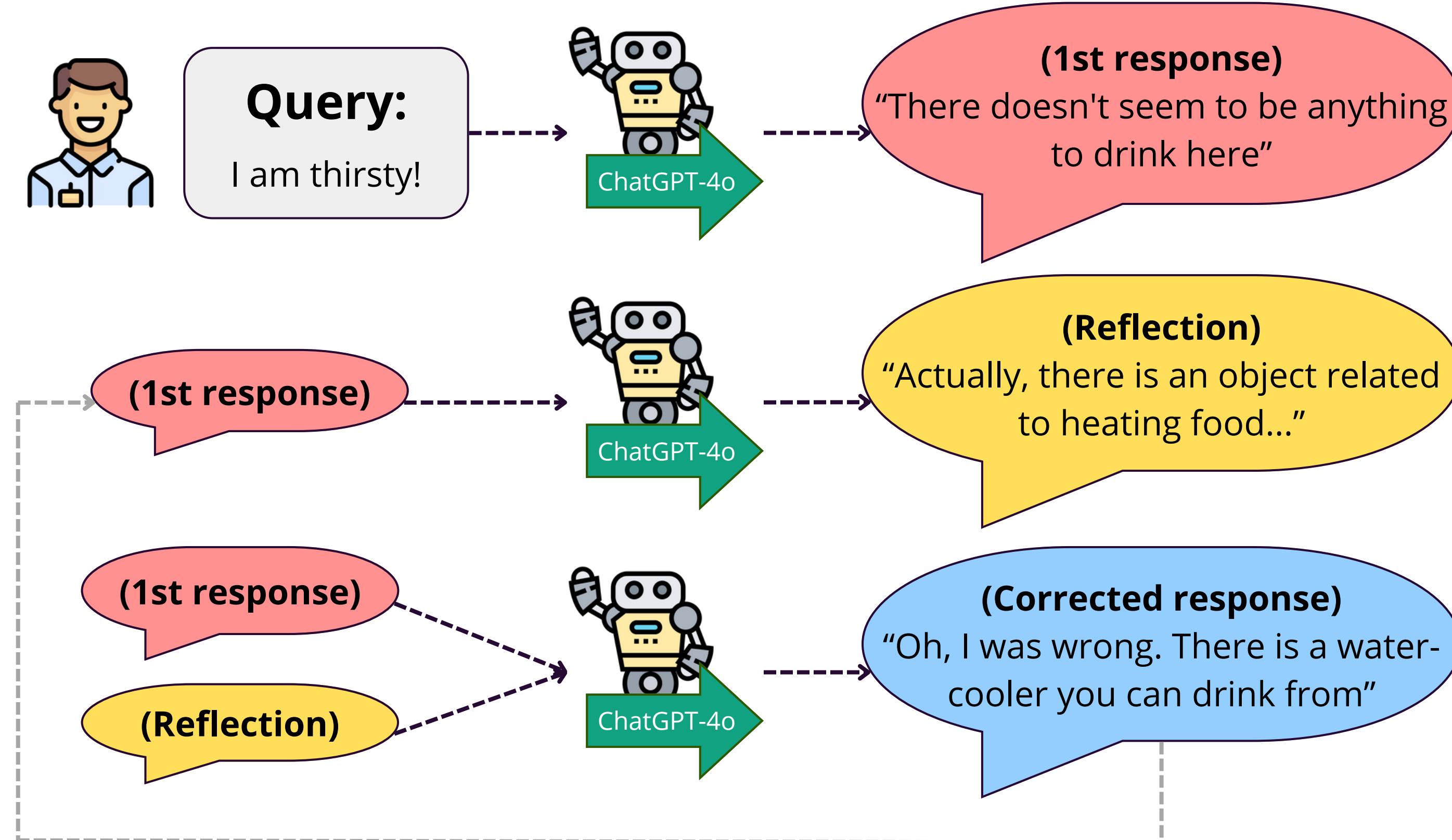


Sure! The most convenient object is <*object*>, because <*explanation*>, follow me!



# Self-reflection

## 4. Semantic mapping method

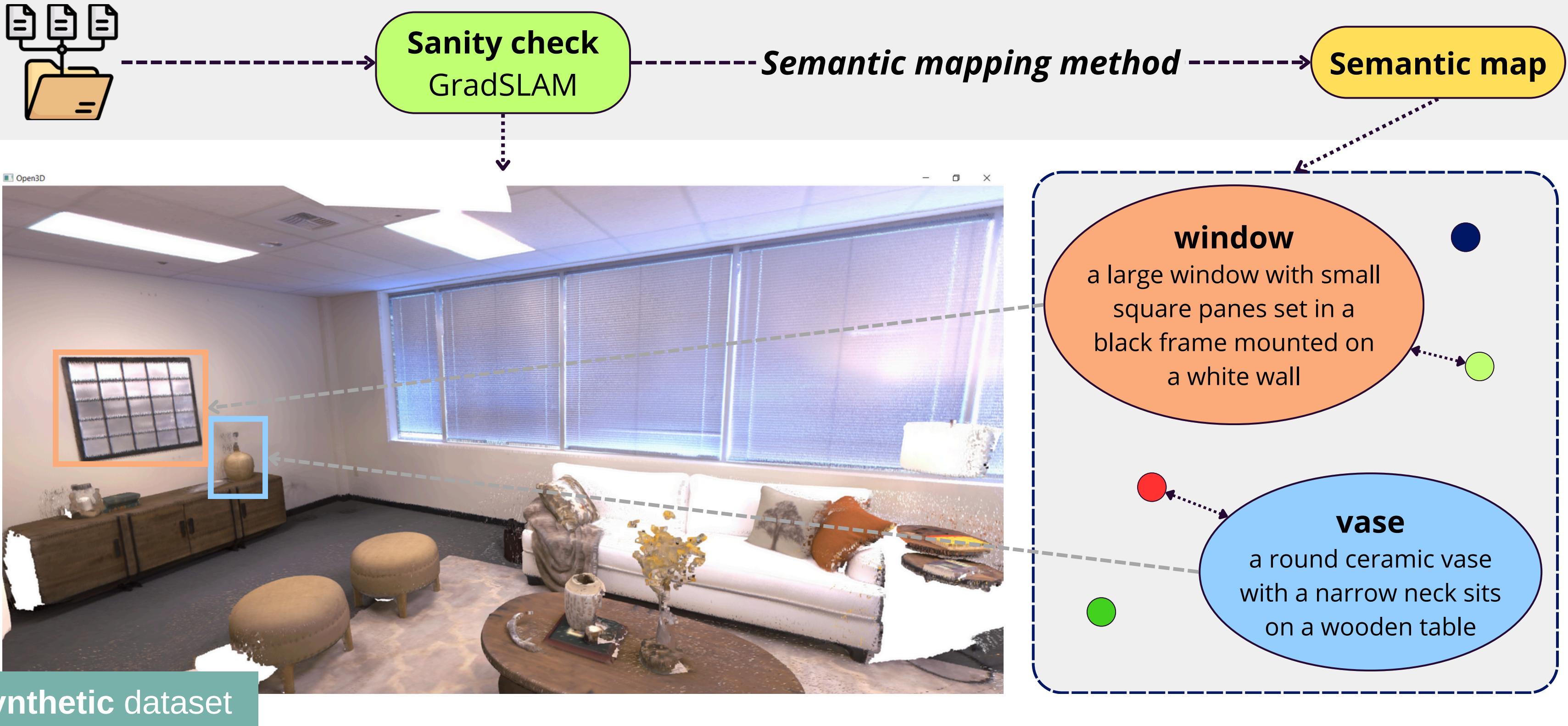


# 5

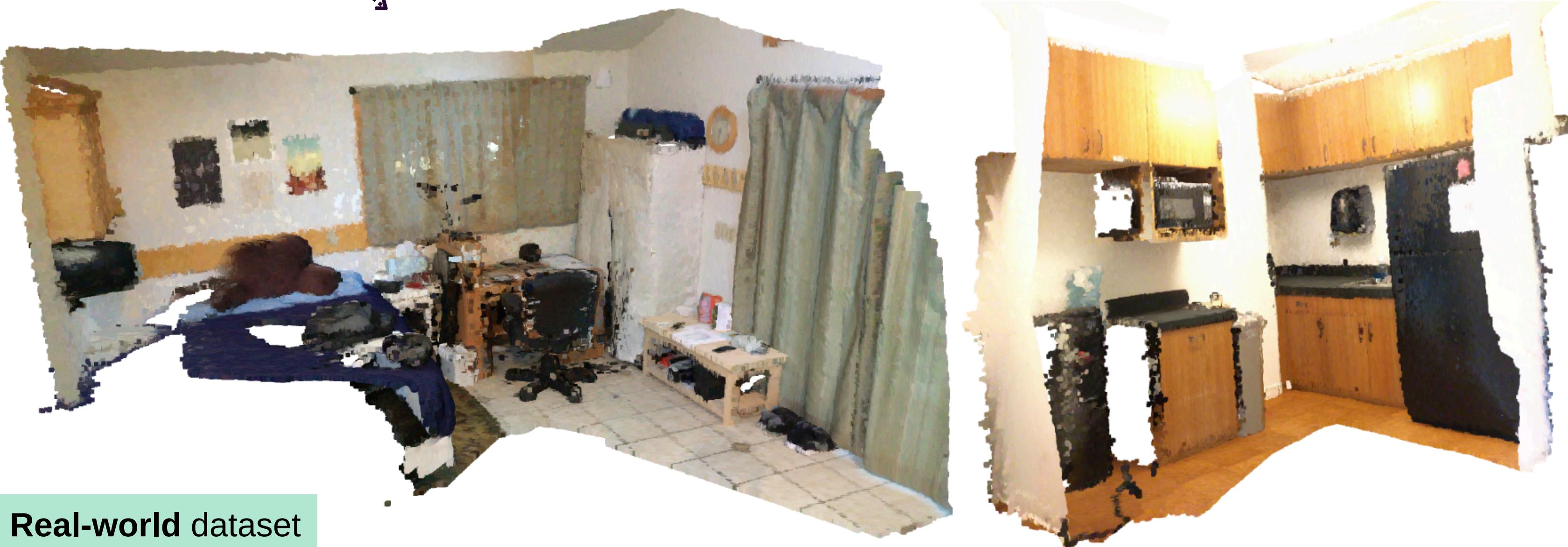
# Validation and testing

# Replica

## 5. Validation and testing



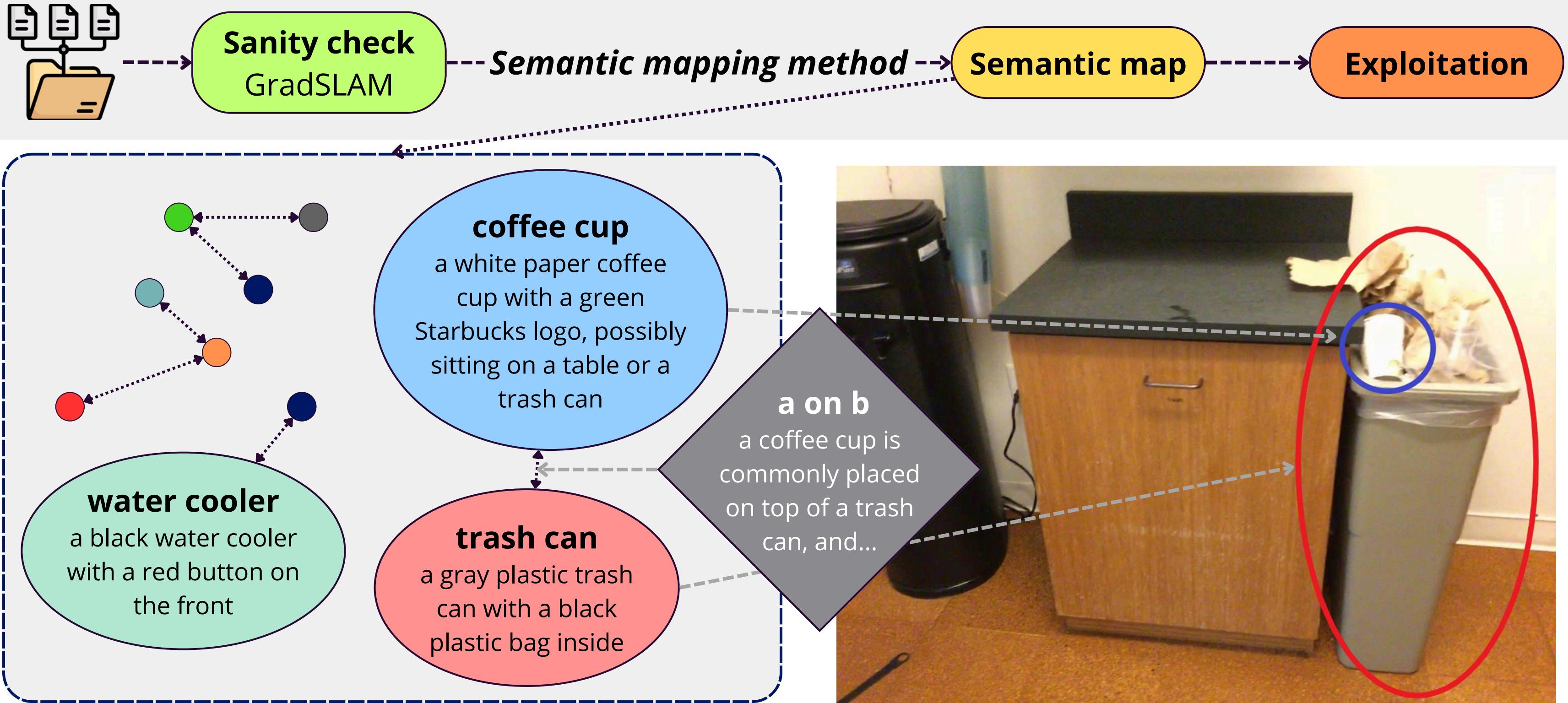
# ScanNet ----- 5. Validation and testing



Real-world dataset

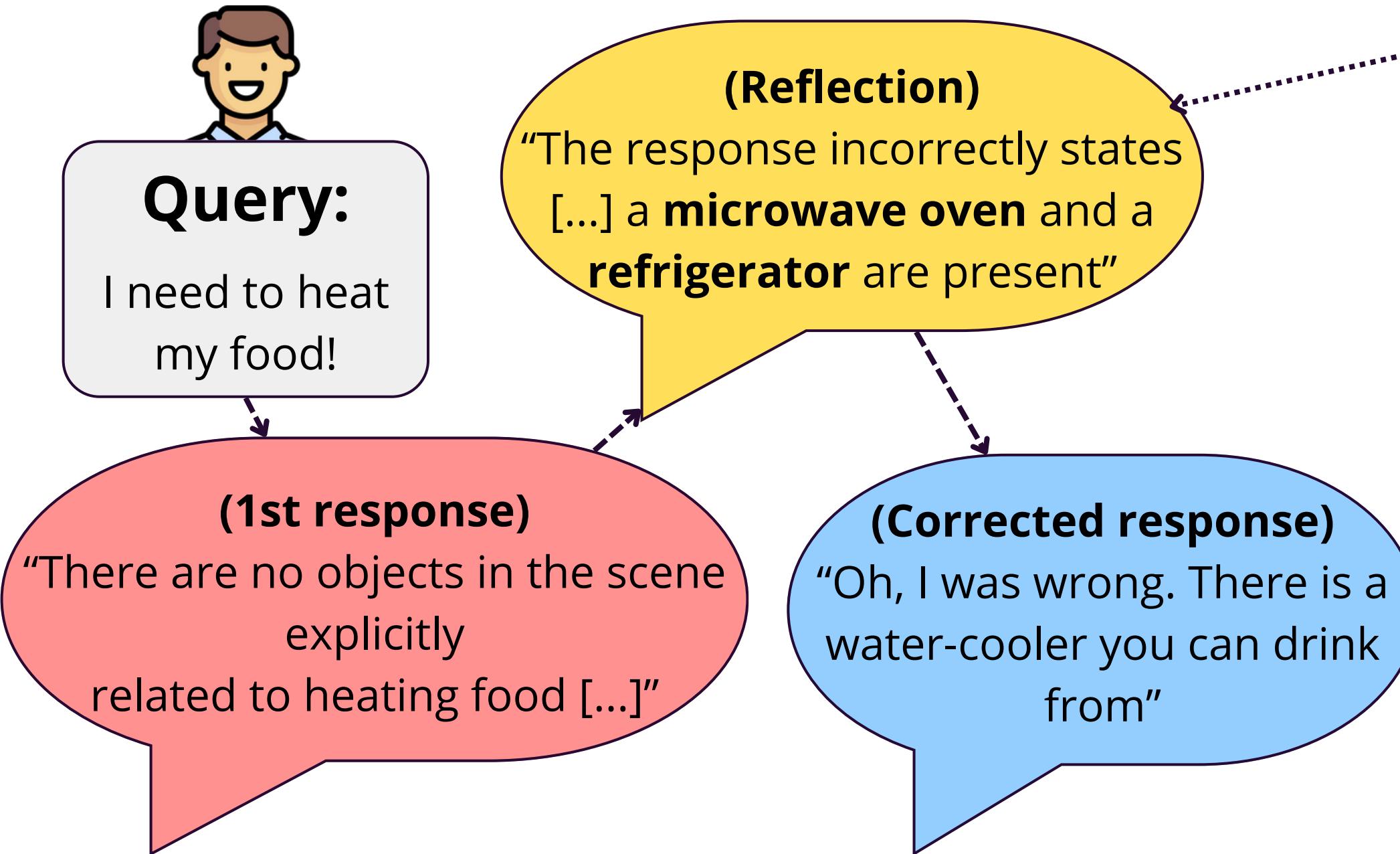
# ScanNet

## 5. Validation and testing



# ScanNet

## 5. Validation and testing



# 6

# Video demonstration

# 7

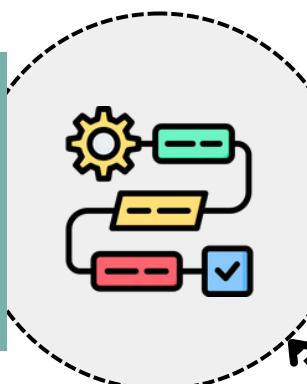
# Conclusions

# Conclusions

## 7. Conclusions

### Semantic mapping method

- Based on ConceptGraphs, using recent **Large Models**.
- Validation on **real-world** and **simulated** datasets.
- Exploitation in an HRI scenario.



### Limitations



Economic and computational **cost**

**SAM** detecting too many objects

**LVLM** errors and hallucinations

### Future lines of research



**Quantitative analysis** of semantic maps

Alternative **object detectors**

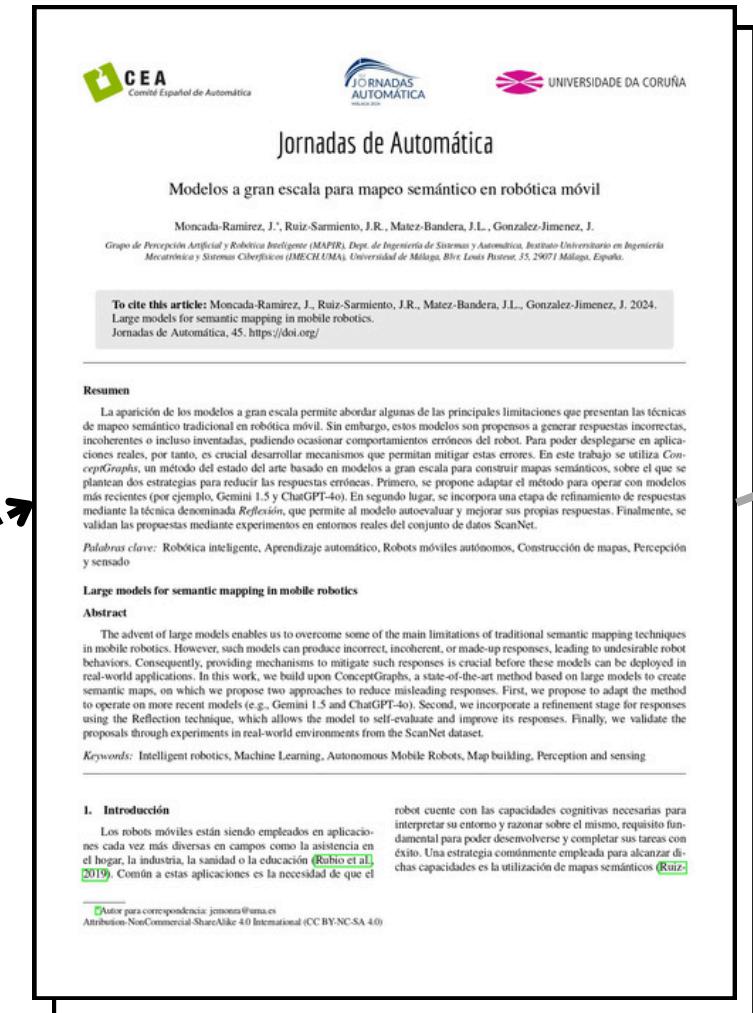
Large-scale **open-source** models

Implementing in a **real** mobile robot

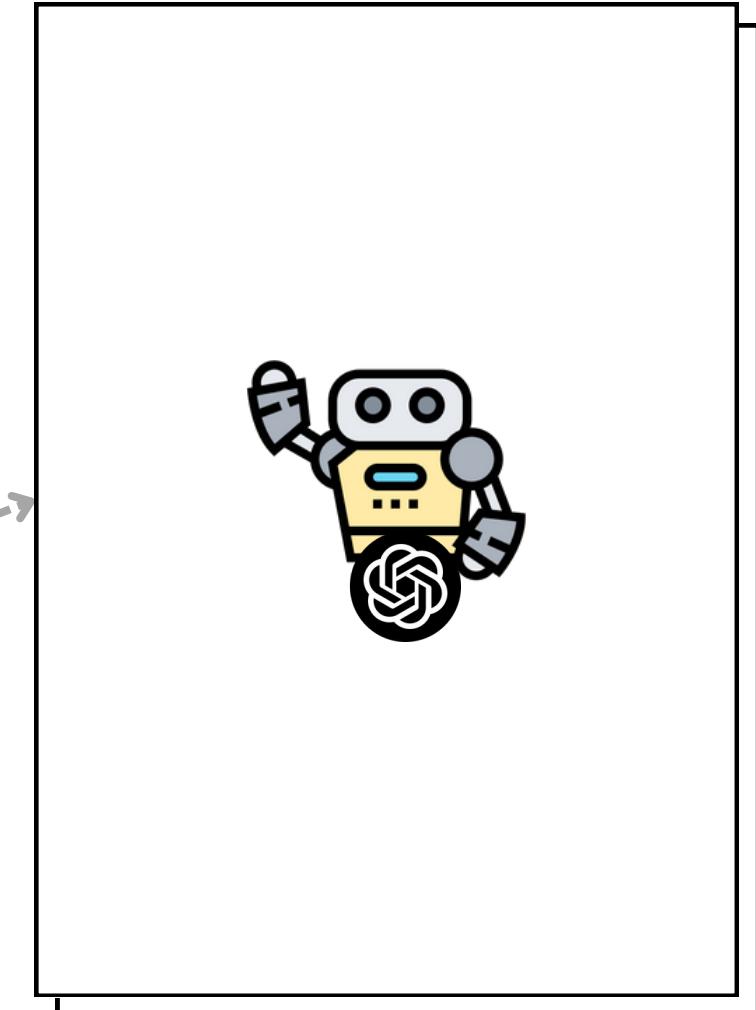
# Future publications ----- 7. Conclusions

Future lines  
of research

Jornadas de  
Automática



Trabajo Fin de  
Grado



Publication in  
an international  
journal

# **Creación y Aprovechamiento de Mapas Semánticos en Robótica Empleando Modelos de Gran Escala**

**Building and Exploiting Semantic Maps in Robotics Using Large  
Models**

Realizado por:

**Jesús Moncada Ramírez**

Tutorizado por:

**Antonio Javier González Jiménez**

**José Raúl Ruiz Sarmiento**

**Grado en Ingeniería Informática**

Málaga, julio de 2024



UNIVERSIDAD DE MÁLAGA