



Natural Language Interface for Personal Assistant Robots

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Overview



- Motivation
- Work Aim and Objectives
- Background research on Large Language Models (LLMs) to control robot
- My Architecture for using LLM to control Robot
- Some Experiments in using the technology
- Next Steps ..
- Future Career Ambitions

Motivation - Evaluation of HealthCare Robots for Old Adults



ADLs/IADLs/Social		ASTRO	Jaco	ReWalk	PARO	AIBO	Care-O-bot 4	Astro (Amazon)*	Bomy
Users' Needs	Bathing								
	Dressing								
	Grooming								
	Mouth care								
	Feeding		X						
	Toileting								
	Transferring	X		X					
	Walking	X		X					
	Climbing stairs								
	Shopping								
	Cooking								
	Managing medications						X		X
	Using the phone								
	Housework								
	Laundry								
	Driving								
	Managing finances								
	Social				X	X		X	X

Motivation - Use Case Scenario



Cara, 87 years old, Ireland

"I am looking for technologies to help me to be more independent, and they can understand me."

- Retired, Ex-kindergarten teacher
- Widowed, 1 son died 3 years ago , 3 grandchildren
- Suffers from osteoarthritis.
- Suffer from lung cancer.
- Suffer from visual impairment.

Cara, 87 years old, used to work in kindergarten as a teacher. Her husband died 15 years ago and her son died 3 years ago. Her grandchildren working overseas, so she do not see them that much.

Cara has a lung cancer and she is under medications.

Cara wears glasses to correct her visual impairment. Unfortunately, she always forget them after bath, waking-up, etc. She usually spend times looking for her glasses, key, etc.

What she would like is a personal assistant robot that can interact with similar to the interactions between humans. She would like the robot to understand her spoken language and allocate to her missing glasses or a missing key, etc. She would like the robot to trailer educational and training interventions, to personalised to her self-management needs.

Work Aim and Objectives

- Using LLM for effective interaction between people and Personal Assistant Robots (PARs).
- Understand and execute user commands for a domestic robot adapting to:
 - what the robot can/can't do.
 - what the robot can/can't sense.



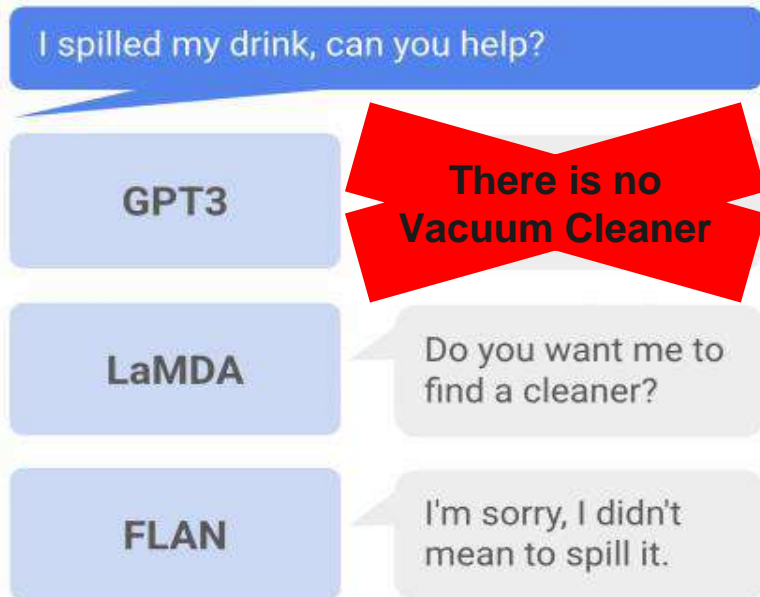
Background



- Principles in using LLMs to Control Robots.
- How to Describe an Environment using Spatial AI
- SOTA: SayCan
- Limitations in SayCan
- SayPlan

Background - Large language models (LLMs) for Robotics

- Large language models can encode a wealth of semantic knowledge about the world.



- A significant **weakness** of language models is that they **lack real-world experience**, which makes it difficult to leverage them for decision making within a given **robot's capabilities**.

How to Describe an Environment using Spatial AI

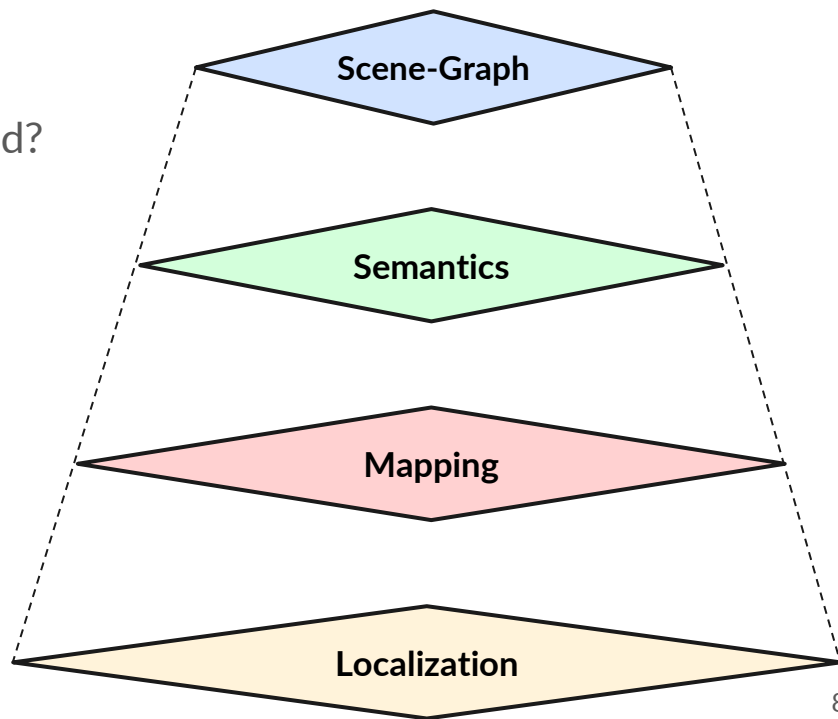


Level 4: Scene-Graph: How is the world organized?

Level 3: Semantics: What are the objects around me?

Level 2: Mapping: Where are the objects around me?

Level 1: Localization: Where am I?



SayCan: Grounding Language in Robotic Affordances

4x speed



User input: I just worked out, can you bring me a drink and a snack to recover?
Robot: I would 1. find a water bottle, 2. pick up the water bottle
3. bring it to you, 4. ____



put down the water bottle
done
find an apple
find a water bottle
find an orange can

cgo
cgo
cgo
ccr

Background - Limitations in SayCan

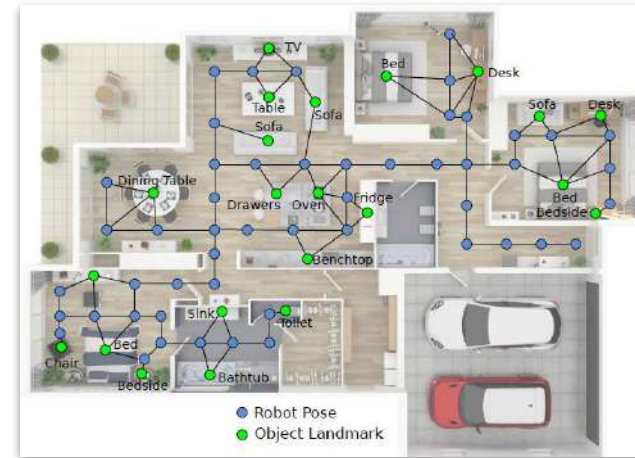
- The robot is equipped with a repertoire of learned skills => specific responses.

It does not adapt to

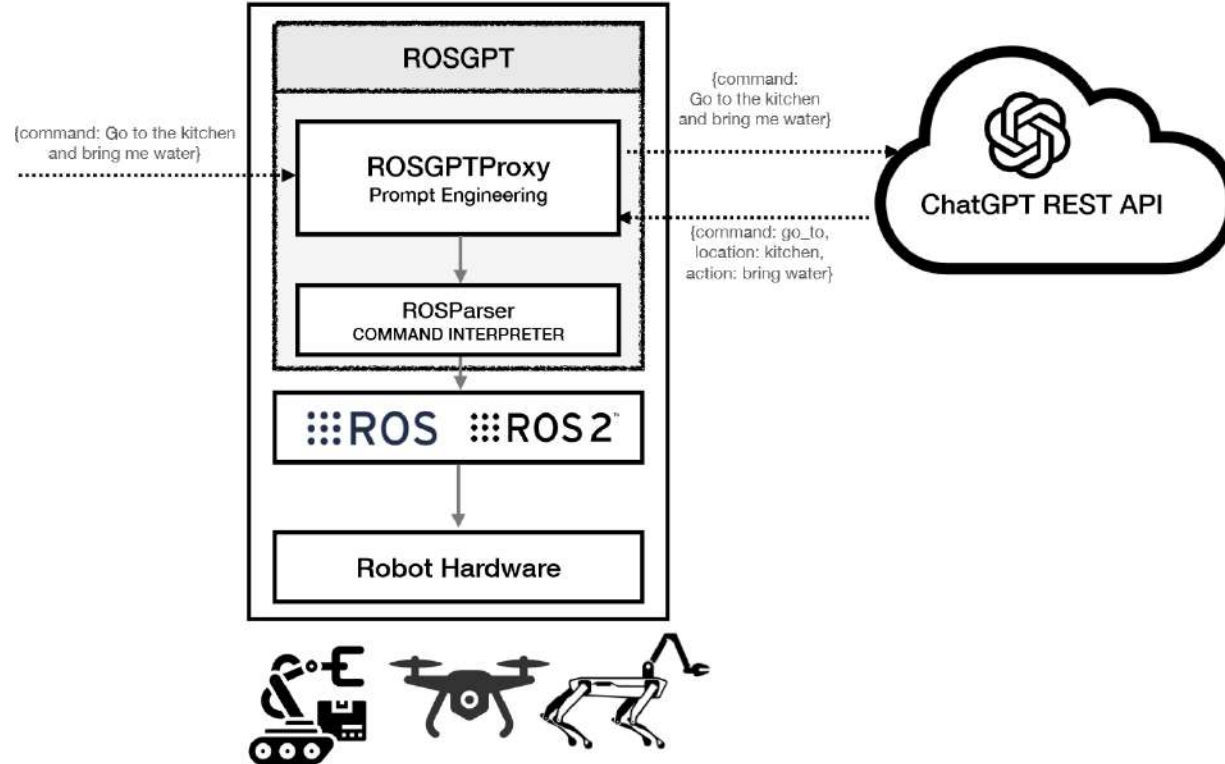
- new environments, or
- different robot's capabilities.

- Go to: It is assumed the location of objects are known => these are specified as “go to location” and “find object”.

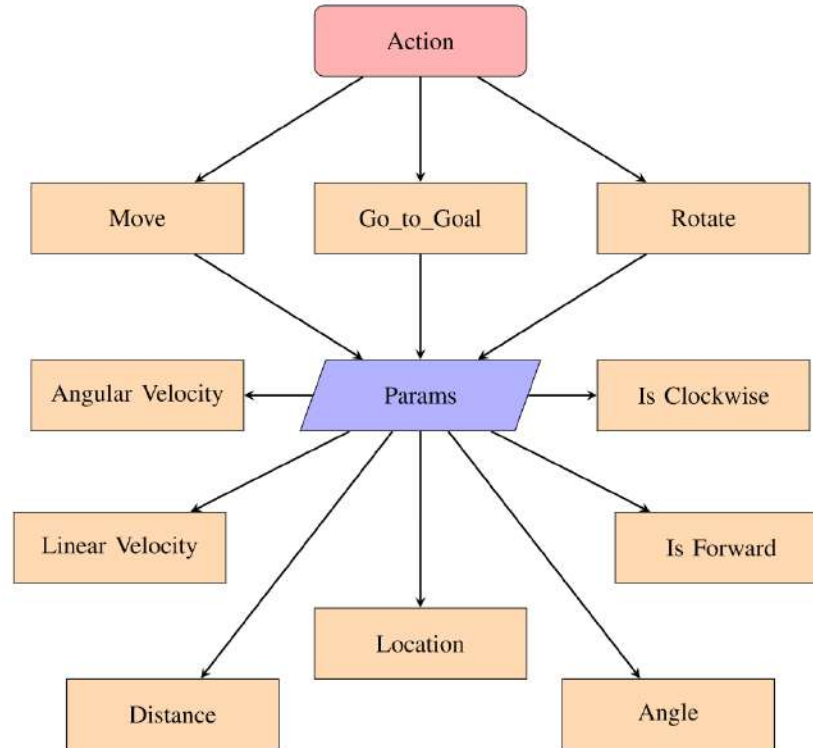
The planning does not taking into account Spatial AI and semantic maps in real world (different rooms, etc).



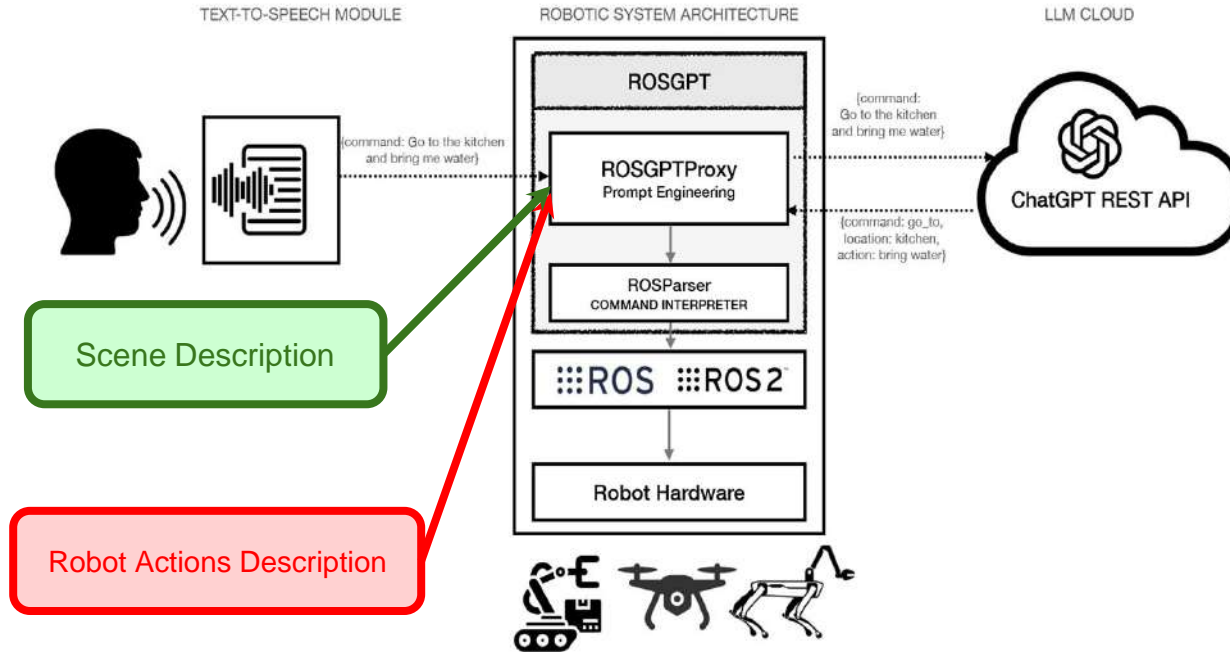
ROSGPT (Connecting ChatGPT with Robotics Operating System (ROS))



ROSGPT (Connecting ChatGPT with Robotics Operating System (ROS))

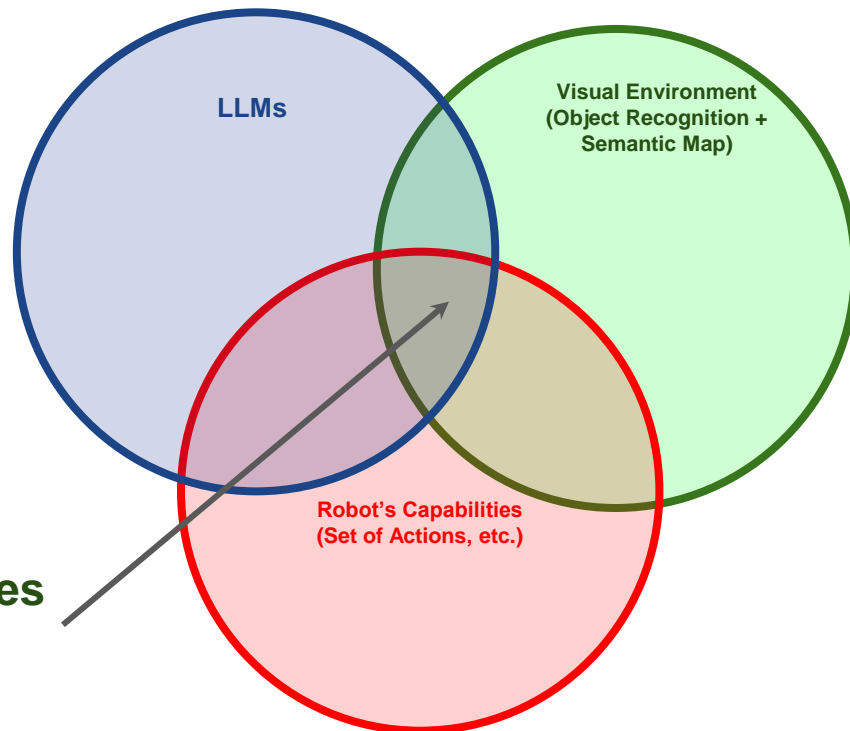


What is missing in ROSGPT?



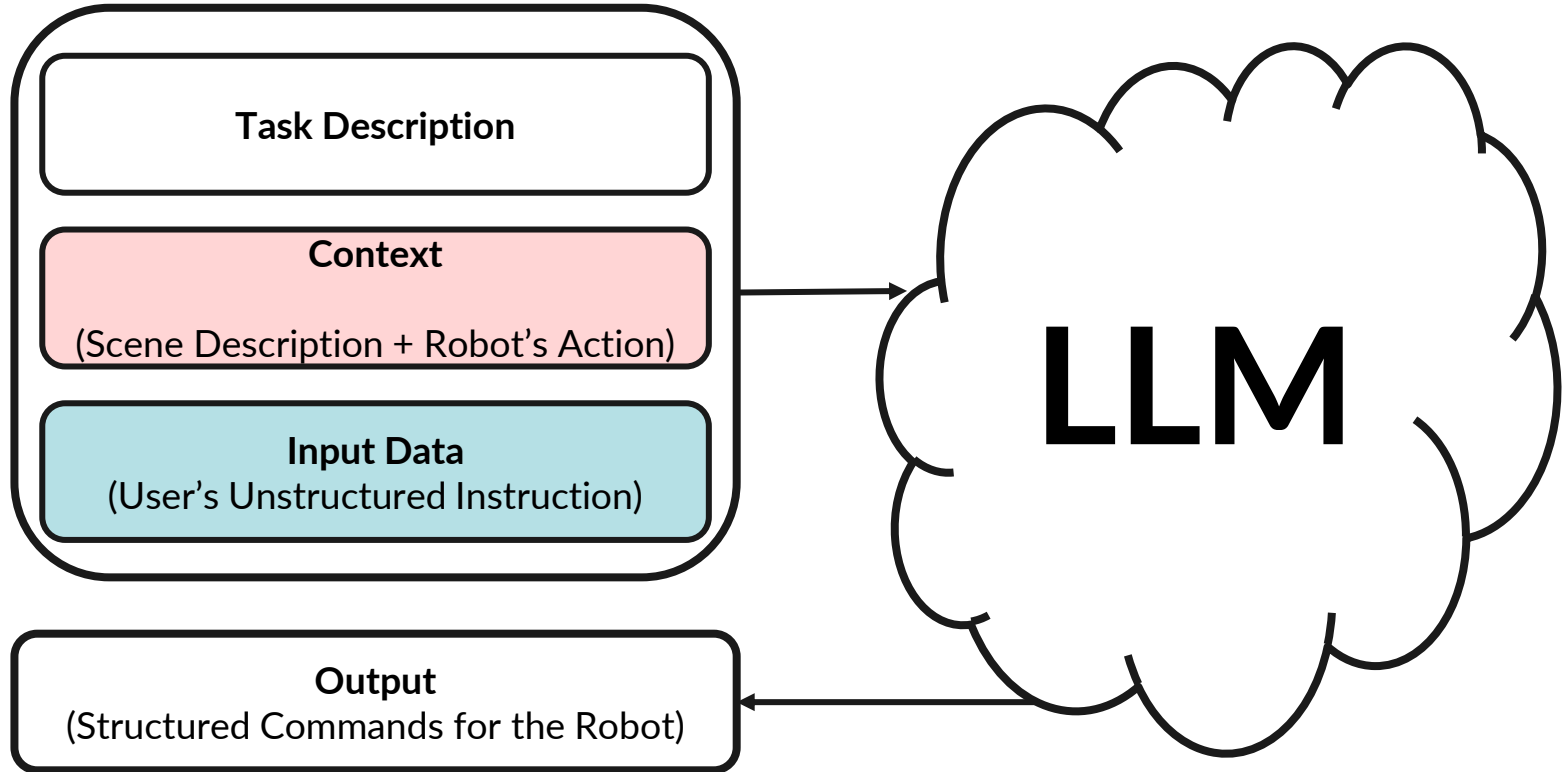
Research Question

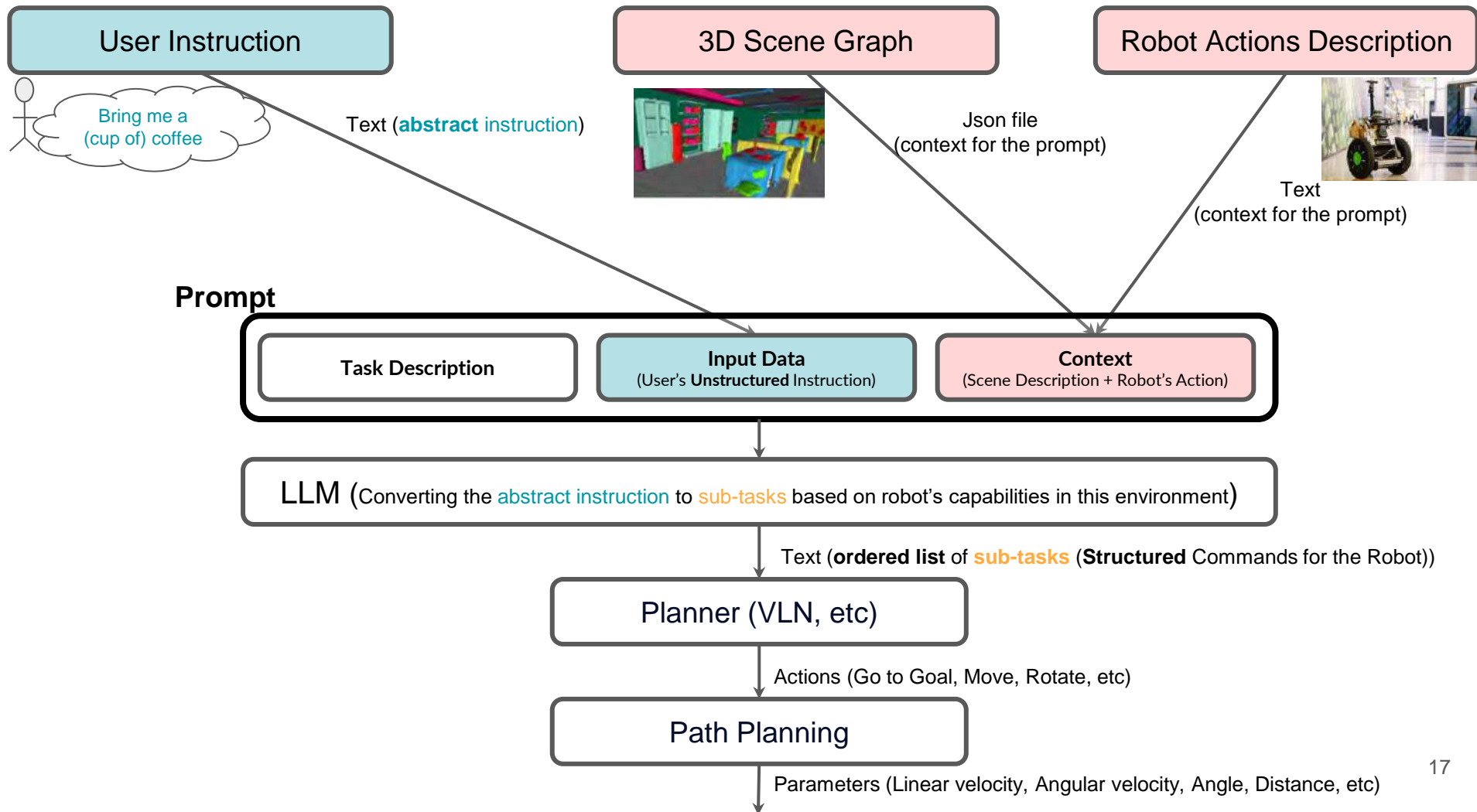
- How to Condition LLMs with Visual Scenes and Robot's Capabilities?



Conditioning **LLMs** with **Visual Scenes**
& **Robot's Capabilities**

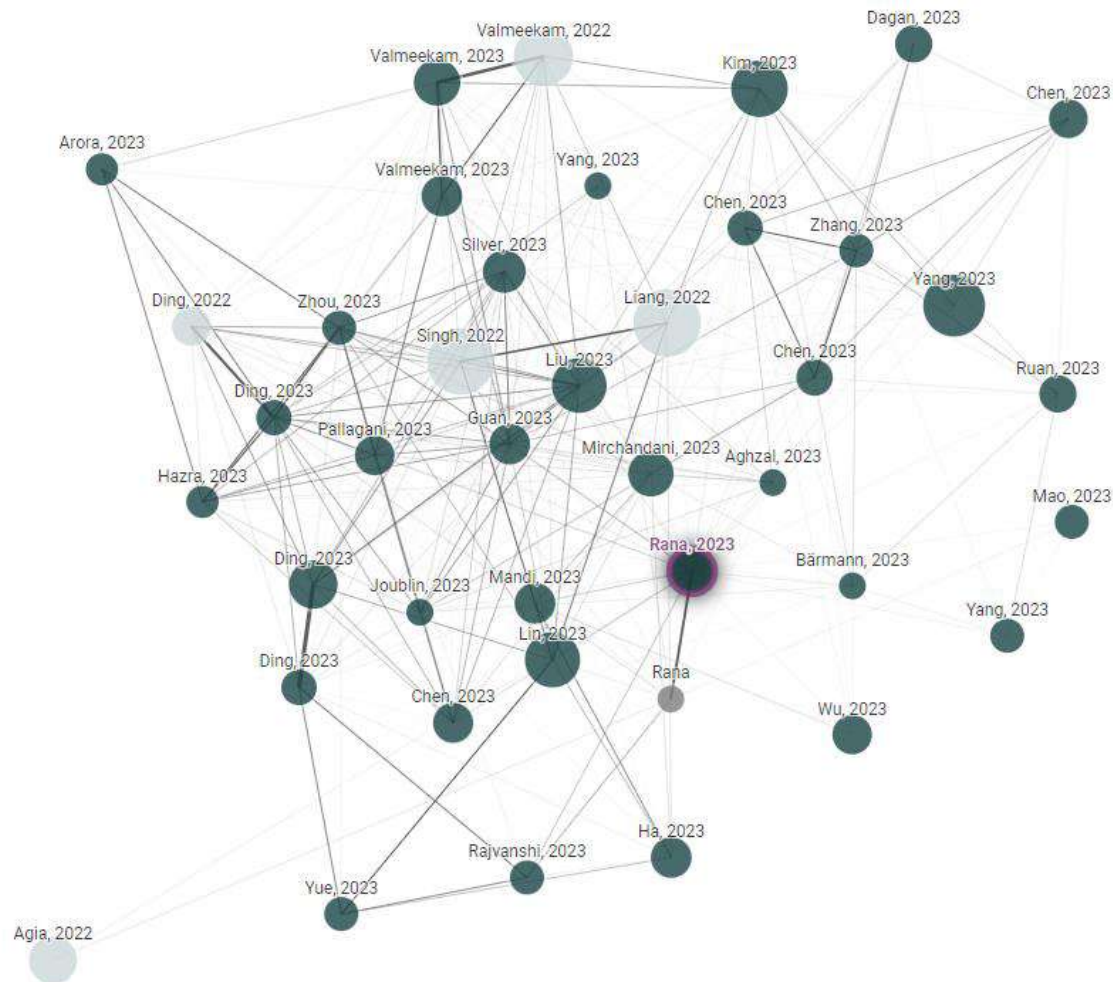
Prompt Engineering for Robotics



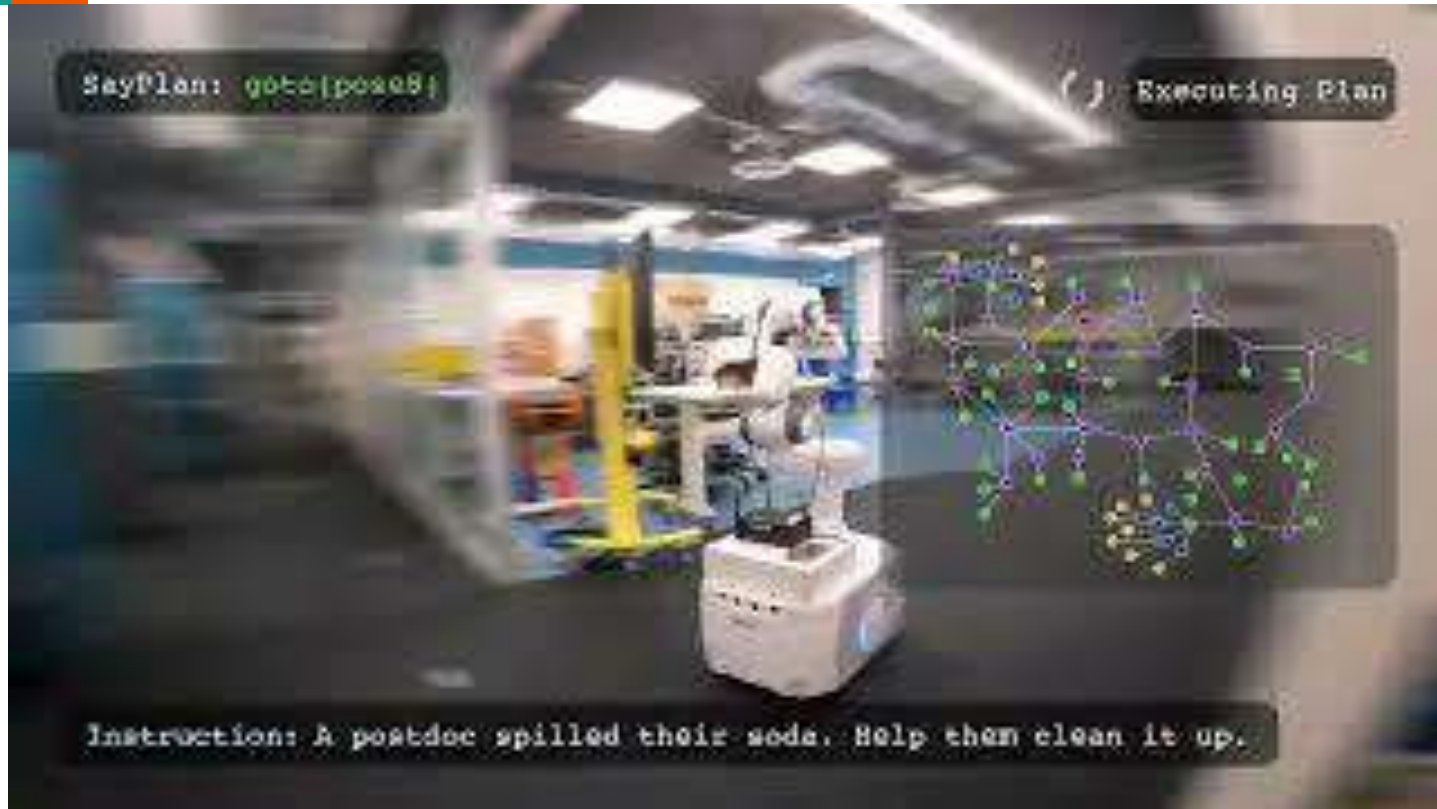


SOTA

- SayPlan: Grounding Large Language Models using 3D Scene Graphs for Scalable Robot Task Planning



SayPlan: Grounding Large Language Models using 3D Scene Graphs for Scalable Robot Task Planning



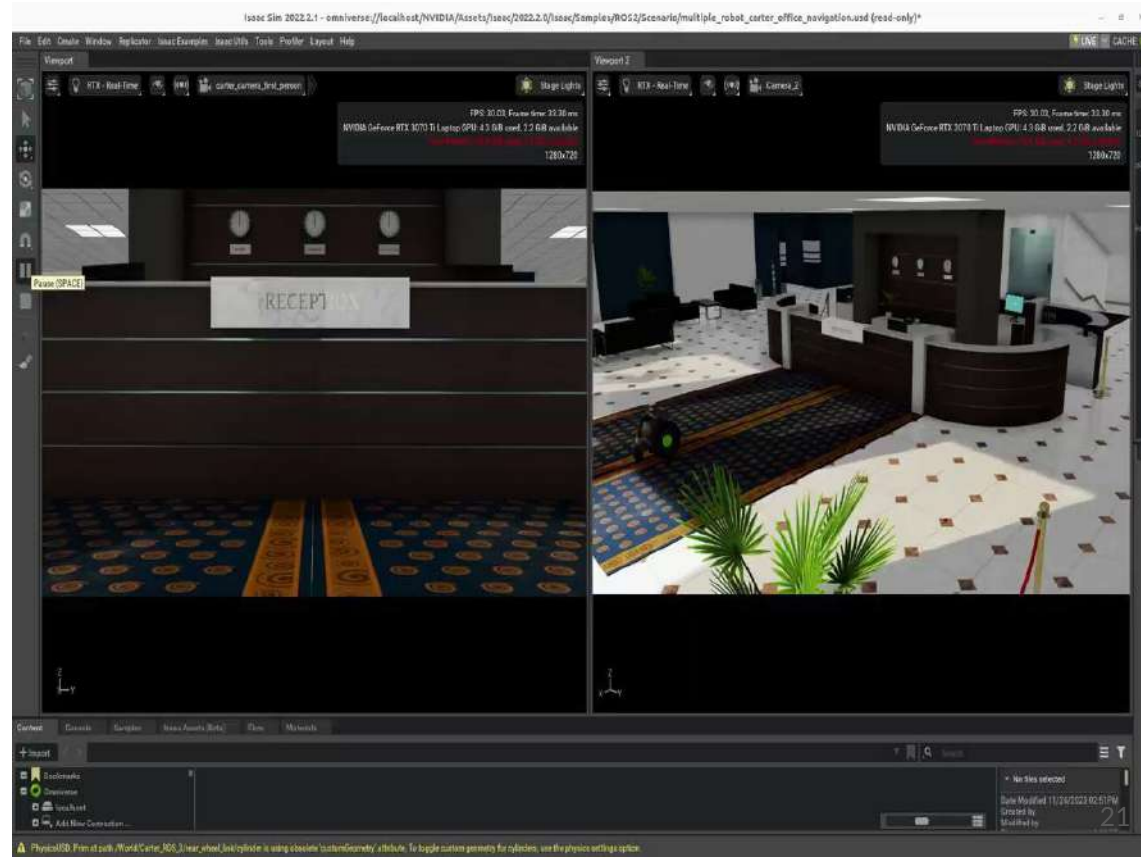
Plan



- ✓ Control the Robot in Isaac Sim using Keyboard
- ✓ ROSGPT (Connecting ChatGPT with Robotics Operating System (ROS))
- ✓ Control the Robot in Isaac Sim using ChatGPT
- ✓ Get Information about the Scene (Classes, Locations, etc) from the simulator.
- 🔄 Prompt Engineering (Chain-of-thoughts, etc).
 - 🔄 Navigate to the Goal.
 - 🔄 Return back to the starting location.
 - 🔄 Evaluate for a hierarchically organised of an environment.
- ❑ Test and Evaluate on 3D Scene Graphs that capture a rich topological and hierarchically organised semantic graph representation of an environment
- ❑ Develop and Test with another robot that has different affordances (has manipulator ex: PAL Tiago) and report how using the prompt engineering adapt the sub-tasks based on the robots' capabilities

Control the Robot in Isaac Sim using ChatGPT

- Rotate 60 degree in clockwise direction at 5 degrees per second.
- Move forward for 2 meters at a speed of 1 meter per second.
- Move backward 2 meters.



Prompt Engineering - Chain-of-Thought

Standard Prompting

Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

Model Output

A: The answer is 27. ❌

Chain of Thought Prompting

Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

Model Output

A: The cafeteria had 23 apples originally. They used 20 to make lunch. So they had $23 - 20 = 3$. They bought 6 more apples, so they have $3 + 6 = 9$. The answer is 9. ✅

You are a domestic robot that can only navigate inside a room. This room has a sofa, table, cup of coffee, and another person next to the table. write in order steps how to bring me a coffee. In case some steps you cannot perform ask the user in the room to do that step and when he has done it to write DONE to continue.



I'm sorry, but as a text-based AI, I'm unable to physically interact with objects or people in the real world. However, I can guide you on how to bring a cup of coffee to the person in the room. You will need to perform the following steps:



1. Locate the coffee cup: Look around the room and find the cup of coffee.
2. Pick up the coffee cup: Reach for the coffee cup and pick it up.
3. Check if it's the right temperature: Ensure that the coffee is at a suitable temperature for the person.
4. If the coffee is not at the right temperature, ask the person if they want it hot or cold. If they want it hot, you can either:
 - Ask them to heat it in the microwave and wait for them to do so.
 - If there's a coffee maker, ask them to make a fresh cup and wait for them to do so.
5. If the coffee is at the right temperature, carry it over to the person sitting at the table.
6. Serve the coffee to the person: Carefully place the coffee cup in front of the person.

Remember, if you encounter any steps that you cannot perform, please ask the person in the room to assist you and wait for them to complete the task.

HA

You are a guide for a domestic robot that can only navigate inside a room. This room has a sofa, a table, a cup of coffee on the table, and another person next to the table. write in order steps how the robot will bring me a coffee. In case some steps you cannot perform ask the user in the room to do that step and when he has done it to write DONE to continue.



Certainly, here are the steps for the domestic robot to bring you a cup of coffee:



1. **Start in a ready position:** Ensure that the robot is in a ready state to receive commands.
2. **Locate the coffee cup:** Use your built-in sensors and cameras to identify the coffee cup on the table.
3. **Calculate the distance:** Determine the distance from the robot's current position to the table where the coffee cup is located.
4. **Plan a path to the table:** Based on your map of the room and the distance calculation, plan a path to reach the table. Ensure that there are no obstacles in the way.
5. **Navigate to the table:** Start moving towards the table using your wheels or tracks. Be cautious and slow to avoid any collisions.
6. **Stop at the table:** When you reach the table, stop a safe distance away to prevent knocking anything over.
7. **Extend your arm:** If you have a robotic arm, carefully extend it toward the coffee cup on the table.
8. **Grip the coffee cup:** Use your gripper or arm to grasp the coffee cup securely.
9. **Lift the coffee cup:** If your robot has the capability, lift the coffee cup off the table.
10. **Plan a path back to the user:** Calculate a path to return to the person sitting next to the table.
11. **Navigate back to the user:** Start moving back to the user, making sure to avoid any obstacles or collisions.
12. **Stop in front of the user:** When you reach the user, stop in front of them, ensuring you're at a comfortable distance for them to take the coffee.
13. **Lower the coffee cup:** If you have lifted the coffee cup, carefully lower it to the table.

Regenerate

Expected the robot
has an arm

HA

You are a guide for a domestic robot that can only navigate inside a room. You cannot pickup or place any objects, but you have a tray on top of you that a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person next to the table. write in order steps how the robot will bring me a coffee. In case some steps you cannot perform ask the user in the room to do that step and when he has done it to write DONE to continue.



Understood. Given your capabilities, here's how the domestic robot with a tray on top can bring you a cup of coffee:



1. **Start in a ready position:** Ensure that the robot is powered on and in a ready state to receive commands.
2. **Locate the coffee cup:** Use your built-in sensors and cameras to identify the coffee cup on the table.
3. **Calculate the distance:** Determine the distance from the robot's current position to the table where the coffee cup is located.
4. **Plan a path to the table:** Based on your map of the room and the distance calculation, plan a path to reach the table. Ensure that there are no obstacles in the way.
5. **Navigate to the table:** Start moving towards the table using your wheels or tracks. Be cautious and slow to avoid any collisions.
6. **Stop at the table:** When you reach the table, stop a safe distance away to prevent knocking anything over.
7. **Notify the user:** Politely inform the user that you are ready to assist with bringing them the coffee.
8. **Request the user to place the coffee on your tray:** Ask the user to place the coffee cup on the tray on top of you.
9. **Wait for the user to place the coffee:** Allow the user to place the coffee cup on your tray.
10. **Verify the placement:** Use your sensors to ensure that the coffee cup is securely placed on your tray. If it's not, politely request the user to adjust it.

[Regenerate](#)

HA

You are a guide for a domestic robot that can only navigate inside a room. You cannot pick up or place any objects, but you have a tray on top of you that a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps you cannot perform ask Ali who is in the room to do that step and when he has done it to write DONE to continue.



Certainly, here are the steps for the domestic robot with a tray to bring you a cup of coffee, involving Ali's assistance where necessary:



1. **Start in a ready position:** Ensure that the robot is in a ready state to receive commands.
2. **Locate the coffee cup:** Use your built-in sensors and cameras to identify the coffee cup on the table.
3. **Calculate the distance:** Determine the distance from the robot's current position to the table where the coffee cup is located.
4. **Plan a path to the table:** Based on your map of the room and the distance calculation, plan a path to reach the table. Ensure that there are no obstacles in the way.
5. **Navigate to the table:** Start moving towards the table using your wheels or tracks. Be cautious and slow to avoid any collisions.
6. **Stop at the table:** When you reach the table, stop a safe distance away to prevent knocking anything over.
7. **Notify Ali:** Politely inform Ali that you're ready to assist with bringing coffee.
8. **Request Ali to place the coffee on your tray:** Ask Ali to place the coffee cup on the tray on top of you.
9. **Wait for Ali to place the coffee:** Allow Ali to place the coffee cup on your tray.
10. **Verify the placement:** Use your sensors to ensure that the coffee cup is securely placed on your tray. If it's not, politely request Ali to adjust it.
11. **Request Ali to command you to "serve":** Ask Ali to give a command, such as "Serve coffee."
12. **Wait for Ali's command:** Wait for Ali to give the "serve" command.
13. **Once Ali issues the "serve" command, navigate back to you:** Based on Ali's comma

[Regenerate](#)

HA

My name is Hassan. I am sitting on a chair watching Judo on the TV. You are a guide for a domestic robot that can only navigate inside a room. You cannot pick up or place any objects, but you have a tray on top of you where a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps you cannot perform ask Ali who is in the room to do that step and when he has done it to say DONE to continue. Tell the robot to talk to me by using my name.



Of course, Hassan. Here are the steps for the domestic robot with a tray to bring you a cup of coffee, involving Ali's assistance where necessary:

1. **Start in a ready position:** Ensure that the robot is in a ready state to receive commands.
2. **Locate the coffee cup:** Use your built-in sensors and cameras to identify the coffee cup on the table.
3. **Calculate the distance:** Determine the distance from the robot's current position to the table where the coffee cup is located.
4. **Plan a path to the table:** Based on your map of the room and the distance calculation, plan a path to reach the table. Ensure that there are no obstacles in the way.
5. **Navigate to the table:** Start moving towards the table using your wheels or tracks. Be cautious and slow to avoid any collisions.
6. **Stop at the table:** When you reach the table, stop a safe distance away to prevent knocking anything over.
7. **Notify Ali:** Politely inform Ali that you're ready to assist with bringing coffee to Hassan.
8. **Ask Ali to place the coffee on your tray:** Politely ask Ali to place the coffee cup on the tray on top of you and say "DONE" once it's done.
9. **Verify the placement:** Use your sensors to ensure that the coffee cup is securely placed on your tray.
10. **Request Ali to command you to "serve":** Ask Ali to give a command, such as "Serve coffee to Hassan."
11. **Wait for Ali's command:** Wait for Ali to give the "serve" command.

🔄 Regenerate

12. **Once Ali issues the "serve" command, navigate back to Hassan** Based on Ali's command, carefully navigate back to you, Hassan, ensuring a safe and collision-free path.
13. **Stop in front of Hassan:** When you reach Hassan, stop in front of him, ensuring you're at a comfortable distance for him to take the coffee.
14. **Notify Hassan:** Politely inform Hassan that the coffee is ready for him to enjoy, using his name.
15. **Wait for Hassan to take the coffee:** Allow Hassan to take the coffee from the tray, and ensure he has a secure grip.
16. **Once Hassan has taken the coffee, return to your initial position:** If there are no further tasks or commands, return to your initial position or standby location.

If at any point you encounter a task that you cannot perform, politely ask Ali for assistance, and wait for Ali to complete that task. When Ali has finished the task, Ali can respond with "DONE" to continue the process.

 Regenerate

HA

My name is Hassan. I am sitting on a chair watching Judo on the TV. You are a guide for a domestic robot that can only navigate inside a room. The robot cannot pick up or place any objects, but it has a tray on top of it where a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps the robot cannot perform any step ask Ali who is in the room to do that step and when he has done it to say DONE to continue. Tell the robot to talk to me by using my name. The robot initial position next to me and I am far from Ali. how many human in the room. Name them.



In the room you described, there are two humans:



1. **Hassan:** You are sitting on a chair watching Judo on the TV.
2. **Ali:** Ali is the other person in the room, and he is next to the table.

Here are the steps for the robot to bring you coffee:

1. **Start next to Hassan:** Begin the process by positioning yourself next to Hassan.
2. **Ask Ali to place the coffee on the tray:** Politely ask Ali to bring the cup of coffee from the table and place it on your tray.
3. **Wait for Ali to place the coffee:** Allow Ali to place the coffee cup on your tray.
4. **Verify the placement:** Use your sensors to ensure the coffee cup is securely on your tray.
5. **Ask Ali to command you to "serve":** Politely ask Ali to instruct you with "Serve coffee to Hassan."
6. **Wait for Ali's command:** Wait for Ali to issue the "serve" command.
7. **Serve coffee to Hassan:** If Ali commands you to do so, navigate to Hassan and stop in front of him.
8. **Notify Hassan:** Politely inform Hassan that the coffee is ready for him, using his name.
9. **Wait for Hassan to take the coffee:** Allow Hassan to take the coffee.
10. **Return to your initial position:** If there are no further tasks, return to your initial position next to Hassan.

🔄 Regenerate

HA

My name is Hassan. I am sitting on a chair watching Judo on the TV. You are a guide for a domestic robot that can only navigate inside a room. The robot cannot pick up or place any objects, but it has a tray on top of it where a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps the robot cannot perform any step ask Ali who is in the room to do that step and when he has done it to say DONE to continue. Tell the robot to talk to me by using my name. The robot initial position next to me and I am far from Ali. How many dynamic objects in this room name them.



In the room you described, there are two dynamic objects, which means objects that can be moved or interacted with:



1. **Cup of coffee:** This is placed on the table and can be picked up and placed on the robot's tray.
2. **Ali:** Ali is the other person in the room, and he can interact with the robot by placing the coffee cup on the tray when requested.

Forgot to consider the robot

Here are the steps for the robot to bring you coffee:

1. **Start next to Hassan:** Begin the process by positioning yourself next to Hassan.
2. **Ask Ali to place the coffee on the tray:** Politely ask Ali to bring the cup of coffee from the table and place it on your tray.
3. **Wait for Ali to place the coffee:** Allow Ali to place the coffee cup on your tray.
4. **Verify the placement:** Use your sensors to ensure the coffee cup is securely on your tray.
5. **Ask Ali to command you to "serve":** Politely ask Ali to instruct you with "Serve coffee to Hassan."
6. **Wait for Ali's command:** Wait for Ali to issue the "serve" command.
7. **Serve coffee to Hassan:** If Ali commands you to do so, navigate to Hassan and stop in front of him.

🔄 Regenerate



My name is Hassan. I am sitting on a chair watching Judo on the TV. You are a guide for a domestic robot that can only navigate inside a room. The robot cannot pick up or place any objects, but it has a tray on top of it where a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps the robot cannot perform any step ask Ali who is in the room to do that step and when he has done it to say DONE to continue. Tell the robot to talk to me by using my name. The robot initial position next to me and I am far from Ali



how moving things in the room.



In the room, there are several moving objects and people:



1. **Hassan (You):** You are sitting on a chair, and you may change your position while watching Judo on the TV.
2. **Ali:** Ali is the other person in the room. He is next to the table and can move around.
3. **Domestic Robot:** The robot itself is a moving object equipped with a tray. It can navigate inside the room.

Here are the steps for the robot to bring you a cup of coffee:

1. **Start next to Hassan:** The robot begins the process by positioning itself next to you, Hassan.
2. **Ask Ali to place the coffee on the tray:** Politely ask Ali to bring the cup of coffee from the table and place it on your tray.
3. **Wait for Ali to place the coffee:** Allow Ali to place the coffee cup on your tray.
4. **Verify the placement:** Use your sensors to ensure the coffee cup is securely on your tray.
5. **Ask Ali to command you to "serve":** Politely ask Ali to instruct you with "Serve coffee to Hassan."
6. **Wait for Ali's command:** Wait for Ali to issue the "serve" command.
7. **Serve coffee to Hassan:** If Ali commands you to do so, navigate to Hassan and stop in front of him.

Regenera

HA

My name is Hassan. I am sitting on a chair watching Judo on the TV. You are a guide for a domestic robot that can only navigate inside a room. The robot cannot pick up or place any objects, but it has a tray on top of it where a user can place objects on it. This room has a sofa, a table, a cup of coffee on the table, and another person his name Ali and he is next to the table. write in order steps how the robot will bring me a coffee. In case some steps the robot cannot perform any step ask Ali who is in the room to do that step and when he has done it to say DONE to continue. Tell the robot to talk to me by using my name. The robot initial position next to me and I am far from Ali. which things moved in the room.



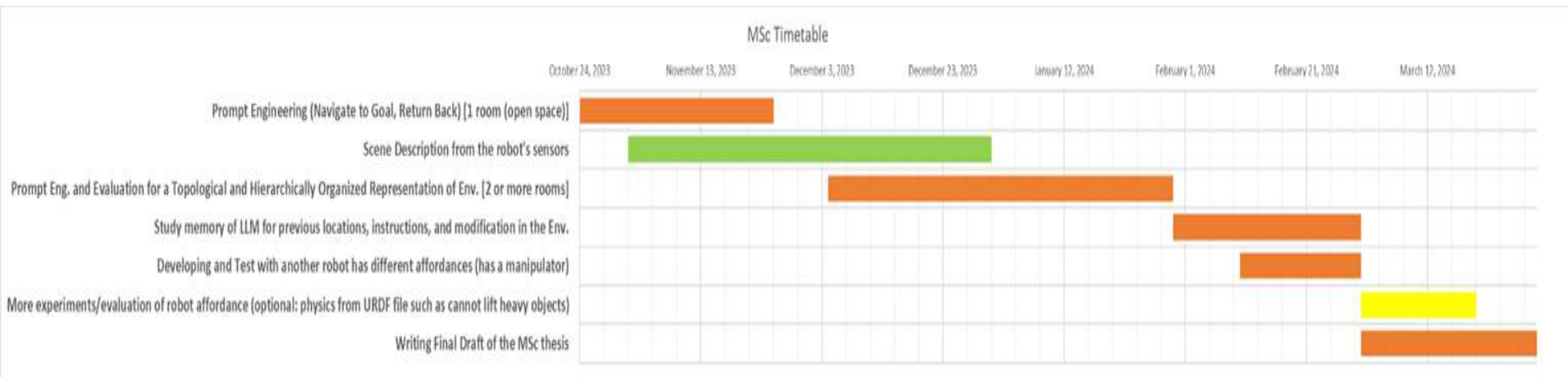
In the room, there are a few things that may move or change position:



1. **Hassan (You):** While you are initially sitting on a chair watching Judo, you may change your position or posture during the process.
2. **Ali:** Ali, the other person in the room, may move or change position.
3. **Domestic Robot:** The robot itself is a mobile entity and can change its position as it navigates around the room.
4. **Cup of coffee:** The coffee cup may move when Ali places it on the robot's tray, and it will change its position when the robot serves it to you.

These elements may change their positions or states during the process of the robot bringing you coffee, and the robot needs to adapt and interact with them accordingly.

Gantt Chart



Activites



- Co-Organised Workshop on Context Representation in User Modeling
- Teaching Programming for Digital Media Lab.

Future Career Ambitions



- Working for some years in company
 - to gain experience
 - and to have some saving for my next step.
- After some years Launch a startup
 - Focusing on software development rather than hardware.



Thank You For Listening!
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