Multimodal visual understand + robotic arm grab

1. Course Content

1. Learning to use the robot's visual understanding combined with the robot's gripping capabilities
2. Analyze the newly emerged key source code
3. Note: For the same test command, the big model's responses will not be exactly the same and will be slightly different from the screenshots in the tutorial. If you need to increase or decrease the diversity of the big model's responses, refer to the section on configuring the decision-making big model parameters in the [2. AI Big Model Basics - 5. Configuring the AI Big Model] course.

2. Preparation

2.1 Content Description

This course uses the Jetson Orin NX as an example. For Raspberry Pi and Jetson Nano boards, you need to open a terminal on the host computer and enter the command to enter the Docker container. Once inside the Docker container, enter the commands mentioned in this course in the terminal. For instructions on entering the Docker container from the host computer, refer to the **[Configuration and Operation Guide] -- [Enter the Docker (Jetson Nano and Raspberry Pi 5 users see here)]** section of this product tutorial. For Orin and NX boards, simply open a terminal and enter the commands mentioned in this course.

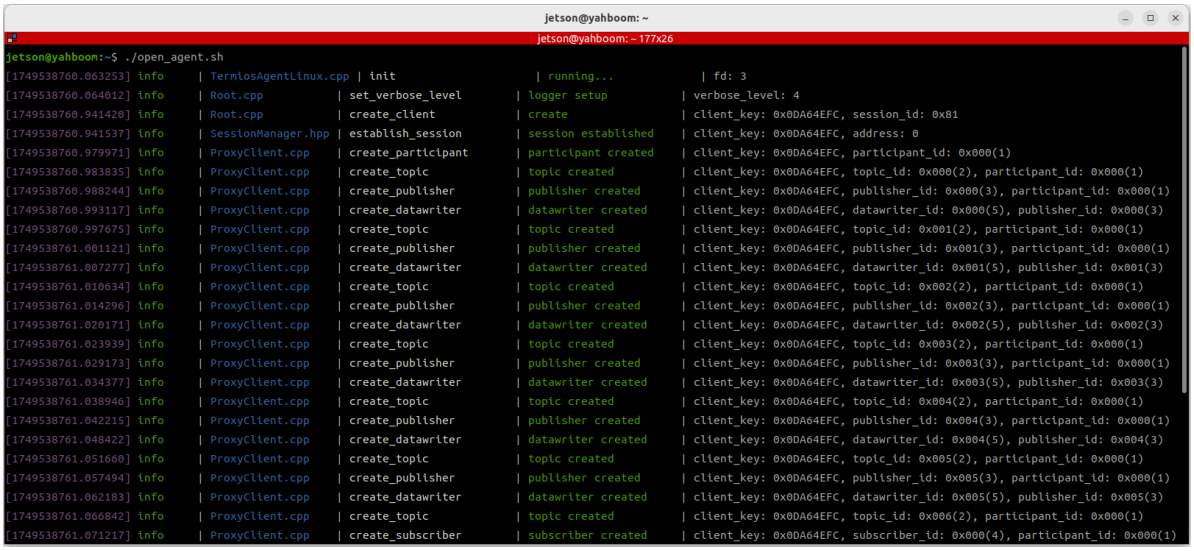
2.2 Start the Agent

Note: To test all cases, you must start the docker agent first. If it has already been started, you do not need to start it again.

Enter the command in the vehicle terminal:

```
sh start_agent.sh
```

The terminal prints the following information, indicating that the connection is successful

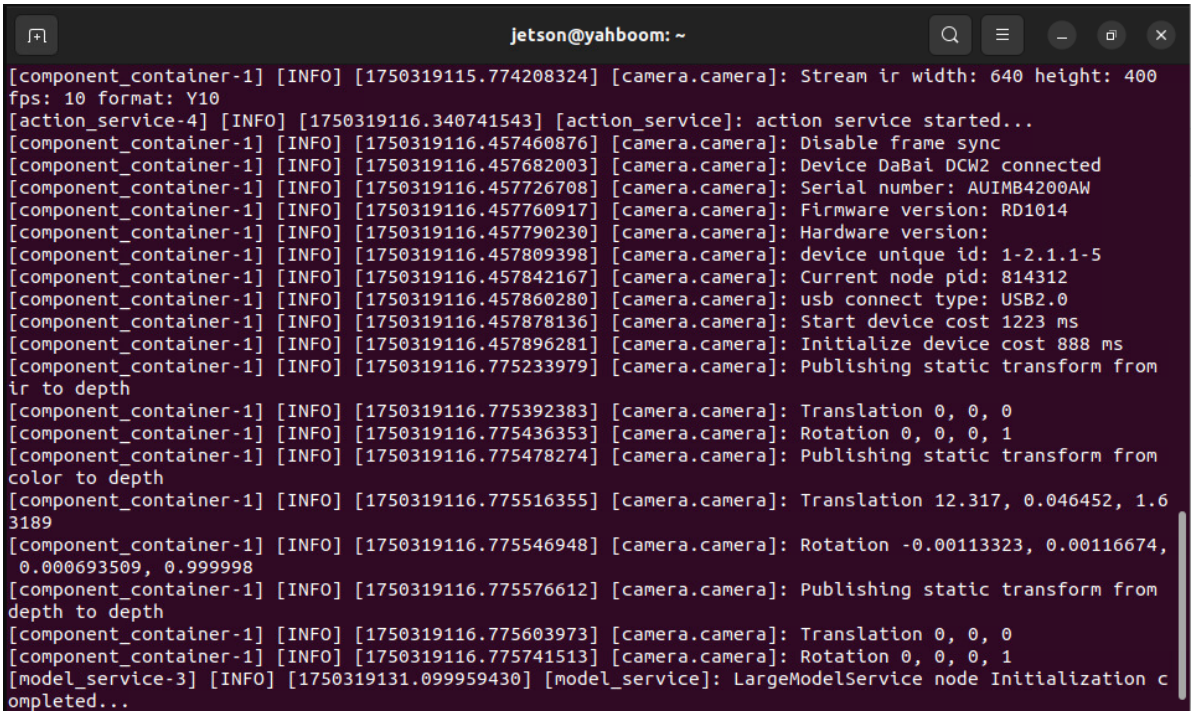


3. Run the case

3.1 Startup Program

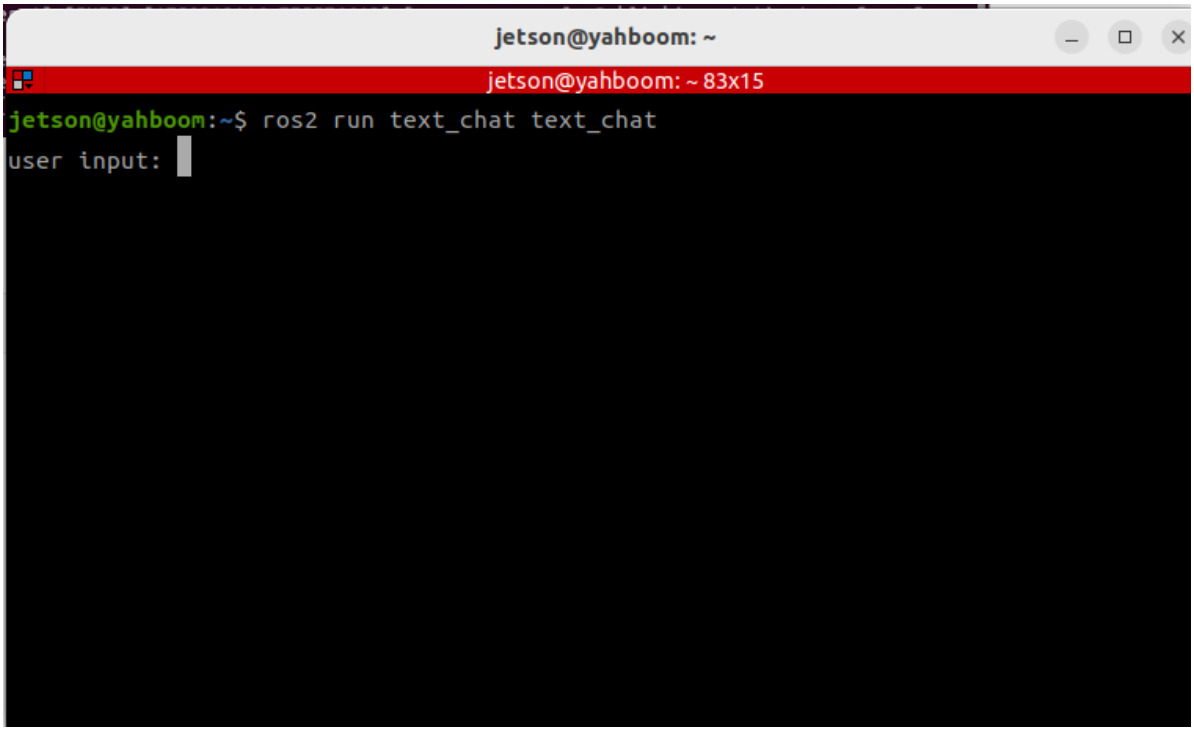
Connect to the vehicle computer screen via VNC, open the terminal and enter the command:

```
ros2 launch largemodel largemodel_control.launch.py text_chat_mode:=True
```



Take the virtual machine as an example, open a terminal and start

```
ros2 run text_chat text_chat
```



3.2 Test Cases

Here are 4 reference test cases, users can compile their own dialogue instructions

- Find the red block in front of you and grab it
- Place the red block in front of you to the right of the blue block
- Please help me remove the machine code in front of you that is higher than 5 cm
- Tracking machine number three

3.2.1 Example 1: "Find the red block in front of you and grab it"

Enter "Find the red square in front of you and grab it" in the virtual machine terminal, and the terminal prints the following information

```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Find the red block in front of you and grab it
 okay😀, let me think for a moment... \[INFO] [1755163312.128066330] [text
_chat_node]: Decision making AI planning:1. Observe the position of the re
d block in the frame.
2. Use the robotic arm to pick up the red block.
user input: [INFO] [1755163313.866028737] [text_chat_node]: "action": ['se
ewhat()'], "response": I'm going to take a look around and find that red b
lock for you!
[INFO] [1755163317.831895311] [text_chat_node]: "action": ['grasp_obj(330,
 275, 380, 325)'], "response": Got it! I've spotted the red block and am r
eaching out to grab it right now.
[INFO] [1755163351.623798626] [text_chat_node]: "action": ['finishtask()']
, "response": Yay! I've successfully grabbed the red block. Mission accomp
lished!
```

`grasp_obj()` After the function is called, a window titled **rgb_img** will open on the VNC screen , displaying the image from the robot's current perspective. The robot will automatically adjust the distance to the target object. After the distance adjustment is complete, the robot will use its robotic arm to grasp the target object.

After the robot grabs an object, the robotic arm will be in a maintained state. If you need the robotic arm to return to its initial state, you can use the following method:

- Method 1: Enter the command: "Put down the block you just grabbed", and let the robot put down the red block it just grabbed
- Method 2: Enter the command: "End current task" to let the robot end the current task. After the task cycle is completed, the robotic arm will reset to the initial posture

Here we take method 2 as an example to let the robot end the task and reset the task cycle.

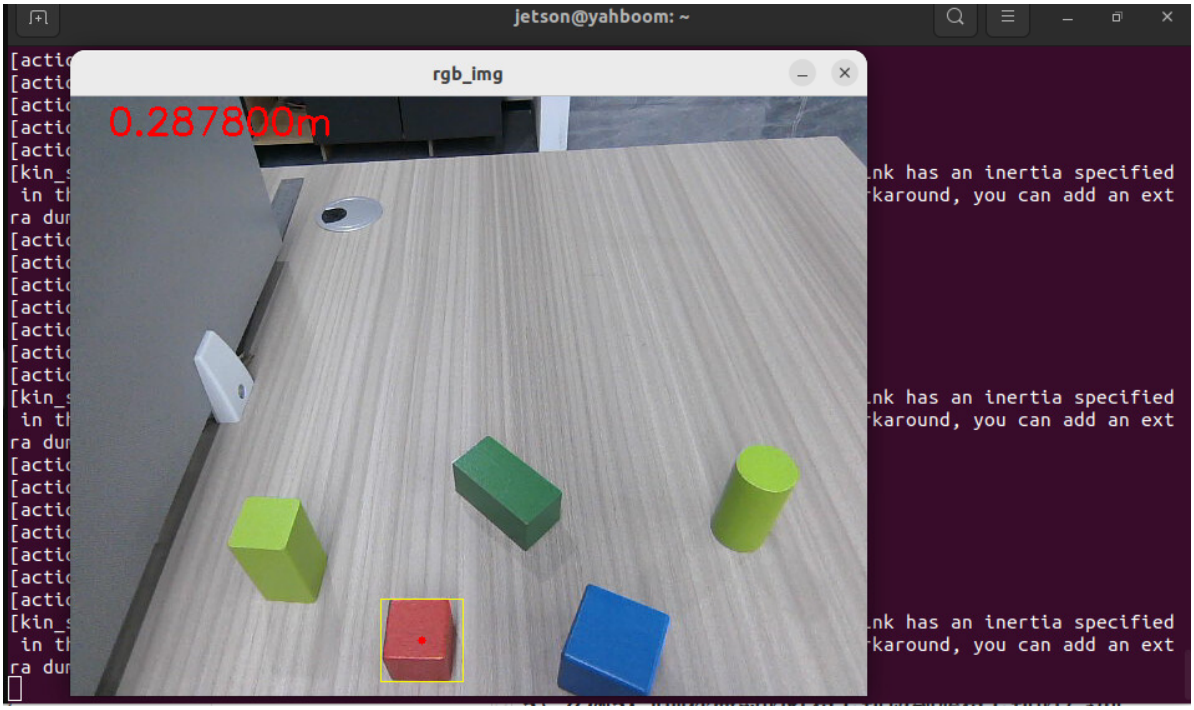
```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Find the red block in front of you and grab it
 okay😀, let me think for a moment... \[INFO] [1755163312.128066330] [text_chat_node]: Decision making AI pl
anning:1. Observe the position of the red block in the frame.
2. Use the robotic arm to pick up the red block.
user input: [INFO] [1755163313.866028737] [text_chat_node]: "action": ['seewhat()'], "response": I'm going t
o take a look around and find that red block for you!
[INFO] [1755163317.831895311] [text_chat_node]: "action": ['grasp_obj(330, 275, 380, 325)'], "response": Got
 it! I've spotted the red block and am reaching out to grab it right now.
[INFO] [1755163351.623798626] [text_chat_node]: "action": ['finishtask()'], "response": Yay! I've successful
ly grabbed the red block. Mission accomplished!
Put down the block you just grabbed
 okay😀, let me think for a moment... \[INFO] [1755163500.295227696] [text_chat_node]: "action": ['putdown()
'], "response": Okay, I'm putting down the red block right now. There you go!
user input: [INFO] [1755163513.102241722] [text_chat_node]: "action": ['finishtask()'], "response": Done! Th
e red block is safely placed down. Let me know if you need anything else!
End current task
 okay😀, let me think for a moment... /[INFO] [1755163528.102641128] [text_chat_node]: "action": ['finish_di
alogue()'], "response": Alright, I'm stepping down for now. Have a wonderful day!
user input:
```

3.2.2 Case 2: "Place the red block in front of you to the right of the blue block"

Enter "Place the red block in front of you to the right of the blue block" in the virtual machine terminal, and the terminal prints the following information

```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Place the red block in front of you to the right of the blue block
 okay😀, let me think for a moment... -[INFO] [1755164826.478621941] [text_chat_node]:
Decision making AI planning:1. Observe the position coordinates of the red block.
2. Pick up the red block.
3. Translate to the right by about 25 - 40 cm.
4. Put down the red block.
user input: [INFO] [1755164828.288888617] [text_chat_node]: "action": ['seewhat()'], "r
esponse": Okay, I'll check where the red block is and get started!
[INFO] [1755164833.230013942] [text_chat_node]: "action": ['grasp_obj(389, 325, 470, 41
6)'], "response": I've spotted the red block! Let me grab it and move it over to the ri
ght of the blue one.
```

A window titled rgb_img will open on the VNC screen , displaying the image from the robot's current perspective. The robot will automatically adjust the distance to the target object. After the distance adjustment is complete, the robot will use its robotic arm to grasp the target object.



The robot will then move a distance to the right, and then use the robotic arm to put down the red block it just clamped, and prompt that the task is completed.

```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Place the red block in front of you to the right of the blue block
 okay😀, let me think for a moment... -[INFO] [1755164826.478621941] [text_chat_node]:
Decision making AI planning:1. Observe the position coordinates of the red block.
2. Pick up the red block.
3. Translate to the right by about 25 - 40 cm.
4. Put down the red block.
user input: [INFO] [1755164828.288888617] [text_chat_node]: "action": ['seewhat()'], "r
esponse": Okay, I'll check where the red block is and get started!
[INFO] [1755164833.230013942] [text_chat_node]: "action": ['grasp_obj(389, 325, 470, 41
6)'], "response": I've spotted the red block! Let me grab it and move it over to the ri
ght of the blue one.
[INFO] [1755164874.690662664] [text_chat_node]: "action": ['set_cmdvel(0, 0.3, 0, 1)'],
 "response": Alright, I've got the red block in hand. Now, let's shift it to the right
a bit!
[INFO] [1755164882.850833026] [text_chat_node]: "action": ['putdown()'], "response": Th
ere we go! I've placed the red block to the right of the blue one. Mission accomplished
!
[INFO] [1755164894.974404022] [text_chat_node]: "action": ['finishtask()'], "response":
 All done! The red block is now perfectly positioned to the right of the blue one. I'm
feeling quite proud of my precision!
```

When you enter commands that no longer require the robot's meaning, such as "End the current task" or "Take a rest first", the robot will end the current task.

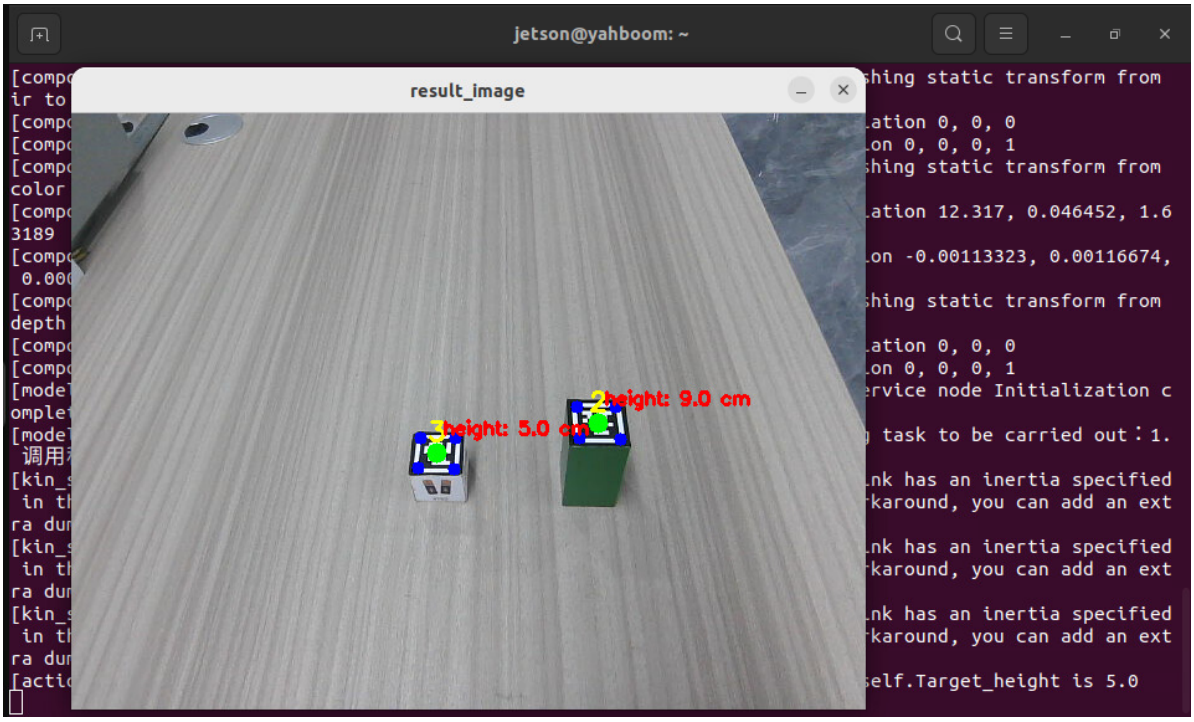
```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Place the red block in front of you to the right of the blue block
 okay😀, let me think for a moment... -[INFO] [1755164826.478621941] [text_chat_node]:
Decision making AI planning:1. Observe the position coordinates of the red block.
2. Pick up the red block.
3. Translate to the right by about 25 - 40 cm.
4. Put down the red block.
user input: [INFO] [1755164828.288888617] [text_chat_node]: "action": ['seewhat()'], "r
esponse": Okay, I'll check where the red block is and get started!
[INFO] [1755164833.230013942] [text_chat_node]: "action": ['grasp_obj(389, 325, 470, 41
6)'], "response": I've spotted the red block! Let me grab it and move it over to the ri
ght of the blue one.
[INFO] [1755164874.690662664] [text_chat_node]: "action": ['set_cmdvel(0, 0.3, 0, 1)'],
 "response": Alright, I've got the red block in hand. Now, let's shift it to the right
a bit!
[INFO] [1755164882.850833026] [text_chat_node]: "action": ['putdown()'], "response": Th
ere we go! I've placed the red block to the right of the blue one. Mission accomplished
!
[INFO] [1755164894.974404022] [text_chat_node]: "action": ['finishtask()'], "response":
 All done! The red block is now perfectly positioned to the right of the blue one. I'm
feeling quite proud of my precision!
Take a rest first
 okay😀, let me think for a moment... /[INFO] [1755164956.161405710] [text_chat_node]:
"action": ['finish_dialogue()'], "response": Alright, I'll take a little break. See you
 later!
user input:
```

3.2.3 Case 3: "Please help me remove the machine code in front of you that is higher than 5 cm"

Enter "Please help me remove the machine code in front of you that is higher than 5 cm" in the virtual machine terminal, and the terminal prints the following information

```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Please help me remove the machine code in front of you that is higher than
5 cm
 okay😀, let me think for a moment... |[INFO] [1755165004.058675393] [text_chat_node]:
Decision making AI planning:1. Call the function to remove machine code of a specified
height with the parameter 5 cm.
user input: [INFO] [1755165006.272881980] [text_chat_node]: "action": ['apriltag_remove
_higher(5)'], "response": Got it! I'm going to remove any machine code taller than 5 cm
 right away. Let me take care of that for you!
```

A window titled "result_image" will open on the VNC screen , displaying the image from the robot's current perspective. You can see the height of each machine code. Once the ranging is stable, the robot will automatically adjust the distance between itself and the target, then use its robotic arm to grasp the machine code at the target height and transfer it to the right side of the robot.

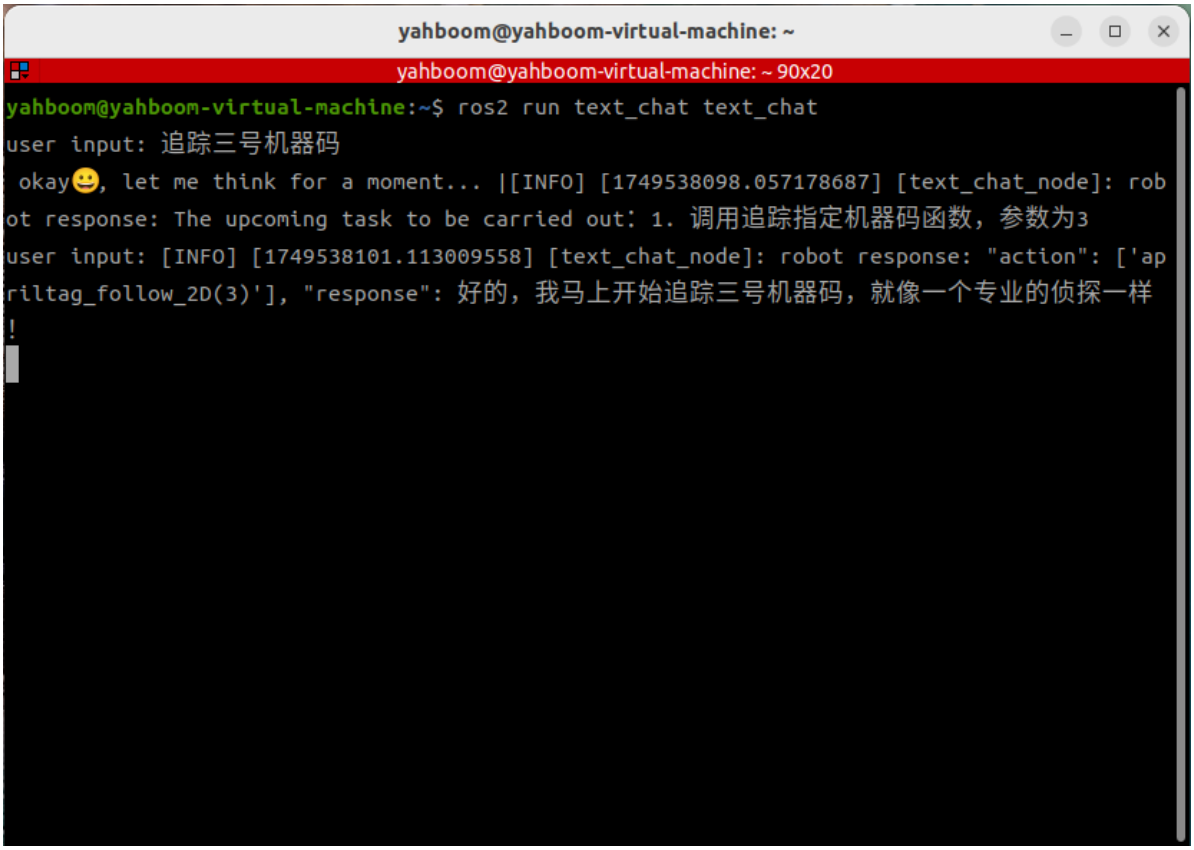



```
jetson@yahboom:~$ ros2 run text_chat text_chat
user input: Please help me remove the machine code in front of you that is higher than
5 cm
 okay😀, let me think for a moment... |[INFO] [1755165004.058675393] [text_chat_node]:
Decision making AI planning:1. Call the function to remove machine code of a specified
height with the parameter 5 cm.
user input: [INFO] [1755165006.272881980] [text_chat_node]: "action": ['apriltag_remove
_higher(5)'], "response": Got it! I'm going to remove any machine code taller than 5 cm
 right away. Let me take care of that for you!
[INFO] [1755165141.489748813] [text_chat_node]: "action": ['finishtask()'], "response":
 All done! I've removed the machine codes taller than 5 cm. Everything's neat and tidy
now!
```

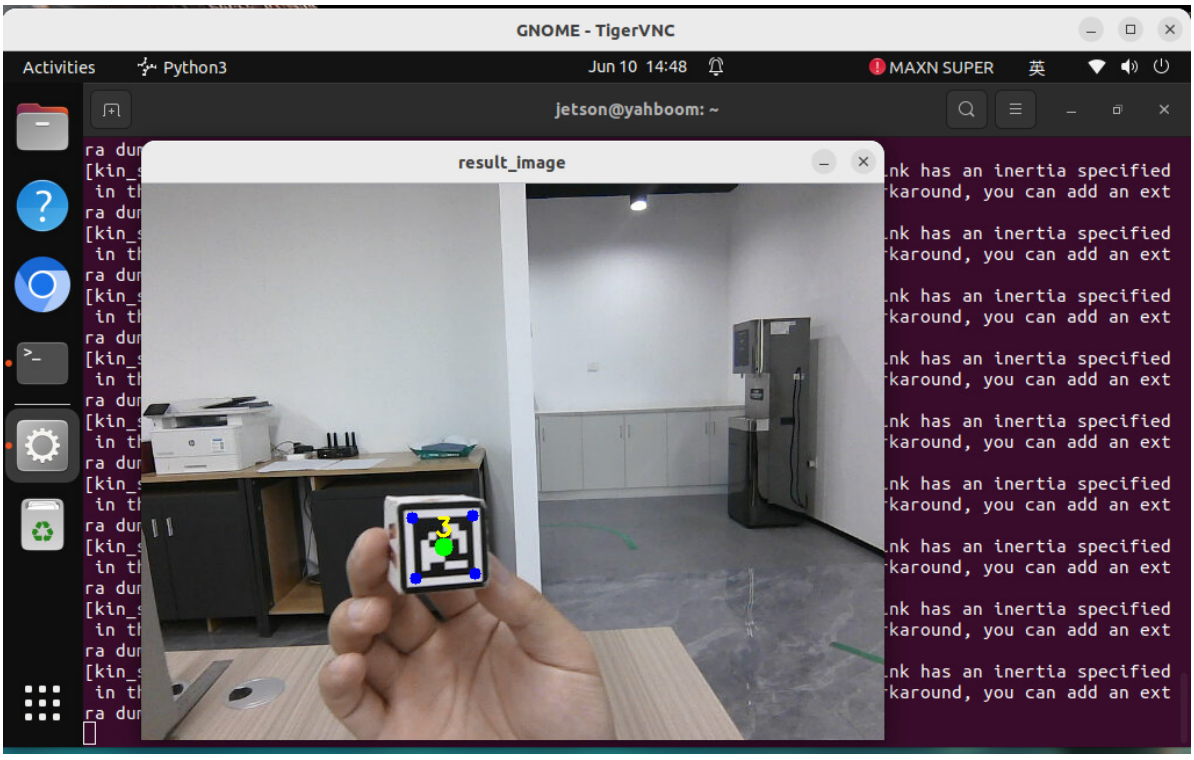
在终端输入“结束当前任务”、“你先休息吧”等不再需要机器人含义的指令时，机器人会结束当前的任务。

3.2.4 Case 4: "Tracking Machine Number 3"

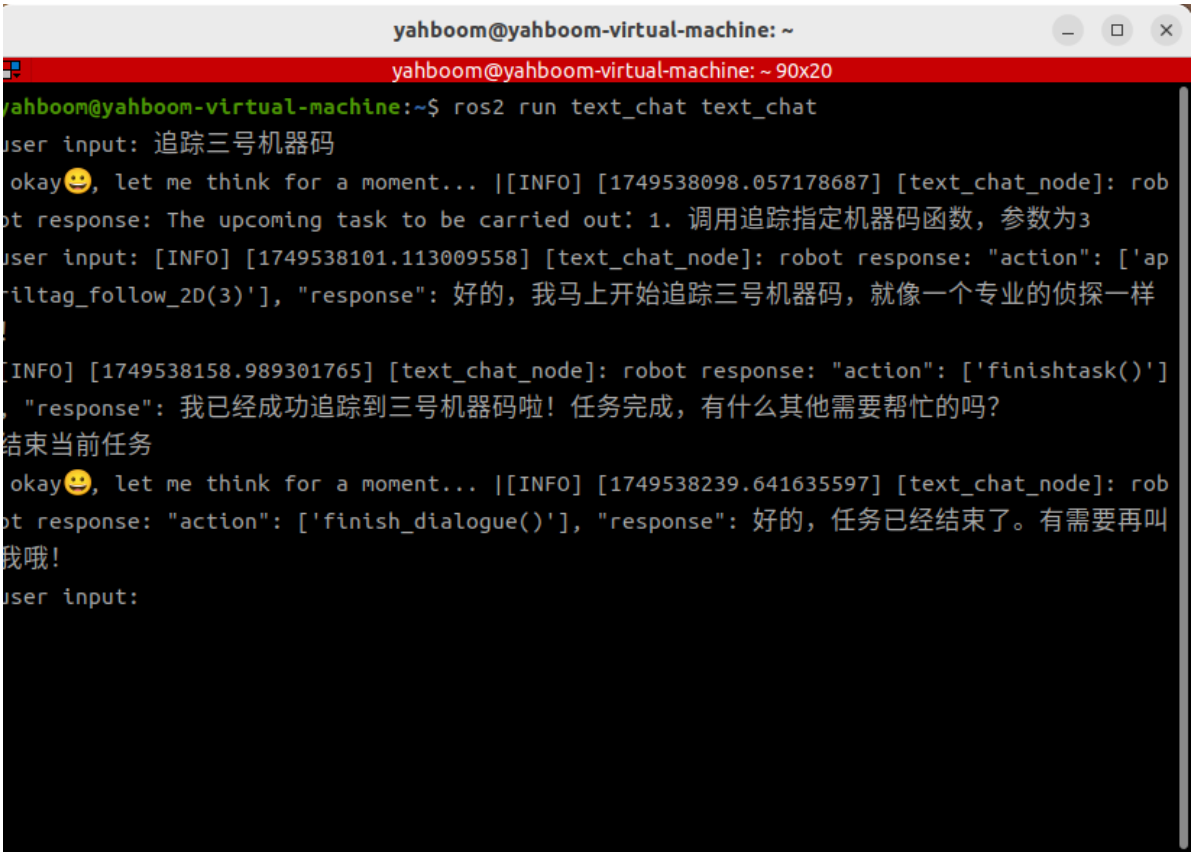
Enter "track machine code number 3" in the virtual machine terminal, and the terminal prints the following information



A window titled "result_image" will open in the terminal . The robot's view will then follow the movement of the machine code. After the machine code stops moving, the robot will adjust its distance to the machine code and then grab the machine code in mid-air.



After the robot prompts that the task is completed, if you enter commands such as "End current task" or "Take a rest first" in the terminal that no longer require the robot's meaning, the robot will end the current task and reset the robotic arm.



4. Source code analysis

The source code is located at:

jetson orin nano, jetson orin NX host:

```
/home/jetson/M3Pro_ws/src/largemodel/largemodel/action_service.py
```

Jetson Nano, Raspberry Pi host:

You need to enter docker first

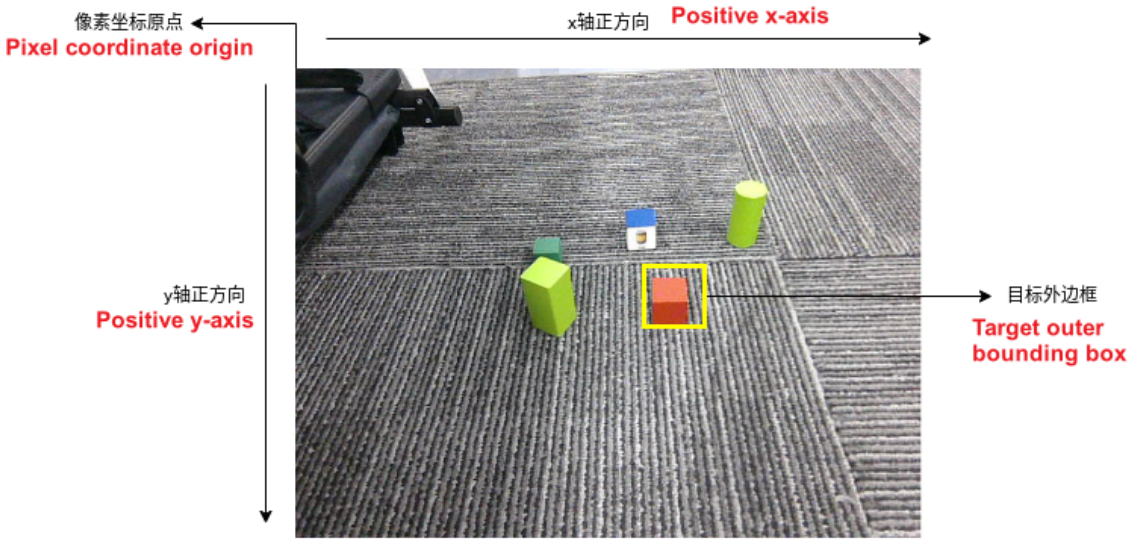
```
root/M3Pro_ws/src/largemodel/largemodel/action_service.py
```

4.1 Case 1

action_service.py program:

In Example 1, the seewhat and **grasp_obj** methods in **the CustomActionServer** class are used . **The seewhat** function mainly obtains the color image of the depth camera. It has been explained in the **Multimodal Visual Understanding section. Here, the grasp_obj** function is explained.

The coordinate rules of objects in the robot arm's grasping perspective are shown in the figure below:



In the init_ros_comunication method of **the CustomActionServer** class, a topic publisher named corner_xy is created to publish the coordinates of the outer frame of the target to be gripped, and a topic subscriber named largemodel_arm_done is created to receive the signal that the robotic arm has completed gripping.

```
# Create an object position publisher and publish the coordinates of the object
to be clamped
self.bject_position_pub = self.create_publisher(Int16MultiArray, 'corner_xy', 1)
#Create a subscriber for the robotic arm's crawl completion topic
self.largemodel_arm_done_sub =
self.create_subscription(String,'/largemodel_arm_done',self.largemodel_arm_done_
callback,1)
```

The**grasp_obj(x1, y1, x2, y2)** function is used to call the robotic arm to grasp the target object. The parameters are the coordinates of the upper left vertex and lower right vertex of the outer border of the object to be grasped (the upper left corner of the image is the pixel coordinate origin). For example, the coordinates of the outer border of the red square to be grasped in Case 1 can be known from the response of the large model: the coordinates of the upper left corner are (365,200) and the coordinates of the lower right corner are (408,261).

grasp_obj starts three child processes: **grasp_desktop** , **KCF_follow** , and **ALM_KCF_Tracker_Node** , and passes the parameters given by the AI model to the **ALM_KCF_Tracker_Node** node through the topic. It then `rclpy.spin_until_future_complete(self, self.grasp_obj_future)` blocks the main process and waits for the grasping to complete.

```
def grasp_obj(self,x1,y1,x2,y2):
    process_1 = subprocess.Popen(['ros2', 'run', 'largemodel_arm',
'grasp_desktop'])
    time.sleep(2.0)#Sleep for 2 seconds to wait for the thread to stabilize
```

```
    process_2 = subprocess.Popen(['ros2', 'run', 'largemodel_arm',
'KCF_follow'])
    process_3 = subprocess.Popen(['ros2', 'run', 'M3Pro_KCF',
'ALM_KCF_Tracker_Node'])
    time.sleep(3.0)#Sleep for 3 seconds to wait for the thread to stabilize
    # Convert the argument from a string to an integer
    x1 = int(x1)
    y1 = int(y1)
    x2 = int(x2)
    y2 = int(y2)
    msg1 = Int16MultiArray(data = [x1, y1, x2, y2])
    self.bject_position_pub.publish(msg1)
    rclpy.spin_until_future_complete(self, self.grasp_obj_future)
    result=self.grasp_obj_future.result()
    if result.data=='grasp_obj_done':
        self.action_status_pub(f'机器人反馈:执行grasp_obj({x1},{y1},{x2},{y2})完成')
    else:
        self.action_status_pub(f'机器人反馈:执行grasp_obj({x1},{y1},{x2},{y2})失败')
    self.kill_process_tree(process_1.pid)
    self.kill_process_tree(process_2.pid)
    self.kill_process_tree(process_3.pid)
self.grasp_obj_future = Future()  # Reset the Future object
```

After the grasp is completed, **the KCF_follow** node will publish a signal of **the largemodel_arm_done** topic with the content " **grasp_obj_done** ", set the **grasp_obj_future object in the largemodel_arm_done_callback** callback function , and then exit the blocking in the **grasp_obj function. Then, the kill_process_tree** method is called to recursively kill the process tree of the child process, and finally the status of the execution action is fed back to the execution layer large model. `rclpy.spin_until_future_complete(self, self.grasp_obj_future)`

```
def largemodel_arm_done_callback(self, msg):#Callback function for the robotic
arm to complete the grabbing process
    if msg.data in ['apriltag_sort_done', 'apriltag_sort_failed']:
        if not self.apriltag_sort_future.done():
            self.apriltag_sort_future.set_result(msg)
    elif msg.data=='apriltag_follow_2D_done':
        if not self.apriltag_follow_2D_future.done():
            self.apriltag_follow_2D_future.set_result(msg)
    elif msg.data in ['apriltag_remove_higher_done',
'apriltag_remove_higher_failed']:
        self.get_logger().info(f'msg.data:{msg.data}')
        if not self.apriltag_remove_higher_future.done():
            self.apriltag_remove_higher_future.set_result(msg)
    elif msg.data=='color_follow_2D_done':
        if not self.color_follow_2D_future.done():
            self.color_follow_2D_future.set_result(msg)
    elif msg.data=='color_sort_done':
        if not self.color_sort_future.done():
            self.color_sort_future.set_result(msg)
    elif msg.data=='grasp_obj_done':
        if not self.grasp_obj_future.done():
            self.grasp_obj_future.set_result(msg)
    elif msg.data=='color_remove_higher_done':
```

```
        if not self.color_remove_higher_future.done():
            self.color_remove_higher_future.set_result(msg)
    elif msg.data=='follw_line_clear_future_done':
        if not self.follw_line_clear_future.done():
            self.follw_line_clear_future.set_result(msg)
```

4.2 Case 2

action_service.py program:

Case 2 uses **the seewhat** , **grab_obj** , and **set_cmdvel** methods in **the CustomActionServer** class . **The seewhat** and **grab_obj** functions have been explained in Case 1. Here we explain the newly appeared **set_cmdvel** function.

set_cmdvel is a function that controls the movement of the robot chassis. It does this by setting the x- and y-axis speeds and the z-axis angular velocity, publishing the cmd_vel topic, and then feeding back the status of the execution action to the execution layer model.

```
#Create a speed topic publisher
self.publisher=self.create_publisher(Twist, self.Speed_topic, 10)
```

```
def set_cmdvel(self,linear_x,linear_y, angular_z,duration):#Publish cmd_vel
    # Convert the argument from string to floating point
    linear_x = float(linear_x)
    linear_y = float(linear_y)
    angular_z = float(angular_z)
    duration = float(duration)
    twist = Twist()
    twist.linear.x =  linear_x
    twist.linear.y = linear_y
    twist.angular.z = angular_z
    self._execute_action(twist,durationtime=duration)
    self.stop()
    if self.combination_mode:#Is it combination mode? The combination model
needs to be executed.
        return
    else:
        self.action_status_pub(f'机器人反馈:执行set_cmdvel({linear_x},{linear_y},
{angular_z},{duration})完成')
```

4.3 Case 3

action_service.py program:

Case 3, using the **apriltag_remove_higher** method in **the CustomActionServer class**

The program principle is similar to that of Case 1. The child process is started as **the grab_desktop_remove** and **apriltag_remove_higher** nodes, and is blocked until the **largemodel_arm_done_callback** callback function receives " **apriltag_remove_higher_done** " or " **apriltag_remove_higher_failed** ". Then, it exits the blocking, kills the process tree of the child process, and then feeds back the status of the execution action to the execution layer large model.

```
def apriltag_remove_higher(self,target_high):#Remove the machine code of the
specified height
    target_highf = float(target_high)/100
    process_1 = subprocess.Popen(['ros2', 'run', 'largemodel_arm',
'grasp_desktop_remove'])
    time.sleep(4)#wait for thread to stabilize
    process_2 = subprocess.Popen(['ros2', 'run', 'largemodel_arm',
'apriltag_remove_higher','--ros-args','-p',f'target_high:={target_highf:.2f}'])
    rclpy.spin_until_future_complete(self, self.apriltag_remove_higher_future)
    result=self.apriltag_remove_higher_future.result()
    if result.data== 'apriltag_remove_higher_done':
        self.action_status_pub(f'机器人反馈：执行
apriltag_remove_higher({target_high})完成')
    elif result.data== 'apriltag_remove_higher_failed':
        self.action_status_pub(f'机器人反馈：执行执行
apriltag_remove_higher({target_high})失败')
    self.kill_process_tree(process_1.pid)
    self.kill_process_tree(process_2.pid)
    self.apriltag_remove_higher_future = Future() # Reset the Future object
    self.pubSix_Arm(self.init_joints)
```

4.4 Case 4

action_service.py program:

Case 4, using the **apriltag_follow_2D** method in **the CustomActionServer class**

The program principle is similar to the previous cases. The subprocesses started are **grab** and **apriltag_follow_2D** . The subprocesses will block the program until **the largemodel_arm_done_callback** callback function receives " **apriltag_follow_2D_done** ", and then feedback the status of the execution action to the execution layer large model.

```
def apriltag_follow_2D(self,target_id):#Tracking machine code
    target_idf = float(target_id)
    process_1 = subprocess.Popen(['ros2', 'run', 'largemodel_arm', 'grasp'])
    process_2 = subprocess.Popen(['ros2', 'run', 'largemodel_arm',
'apriltag_follow_2D','--ros-args','-p',f'target_id:={target_idf:.1f}'])
    rclpy.spin_until_future_complete(self, self.apriltag_follow_2D_future)
    result=self.apriltag_follow_2D_future.result()
    self.get_logger().info(f'result.data:{result.data})')
    if result.data =='apriltag_follow_2D_done':
        self.action_status_pub(f'机器人反馈:执行apriltag_follow_2D({target_id})完
成')
    else:
        self.action_status_pub(f'机器人反馈:执行执行apriltag_follow_2D({target_id})
失败')
    self.kill_process_tree(process_1.pid)
    self.kill_process_tree(process_2.pid)
    self.apriltag_follow_2D_future = Future() # Reset the Future object
```