Embodied intelligent functions core source code

1. Course Content

1. Embodied AI gameplay using large language models is a complex function involving the coordinated operation of multiple program nodes. This section of the course will explain the core programs involved.

2. Source Code Package Structure

2.1 Function Package File Structure

The ROS function package for the AI large model embodied intelligence is `largemodel`, and the package path is:

Jetson Orin Nano, Jetson Orin NX host:

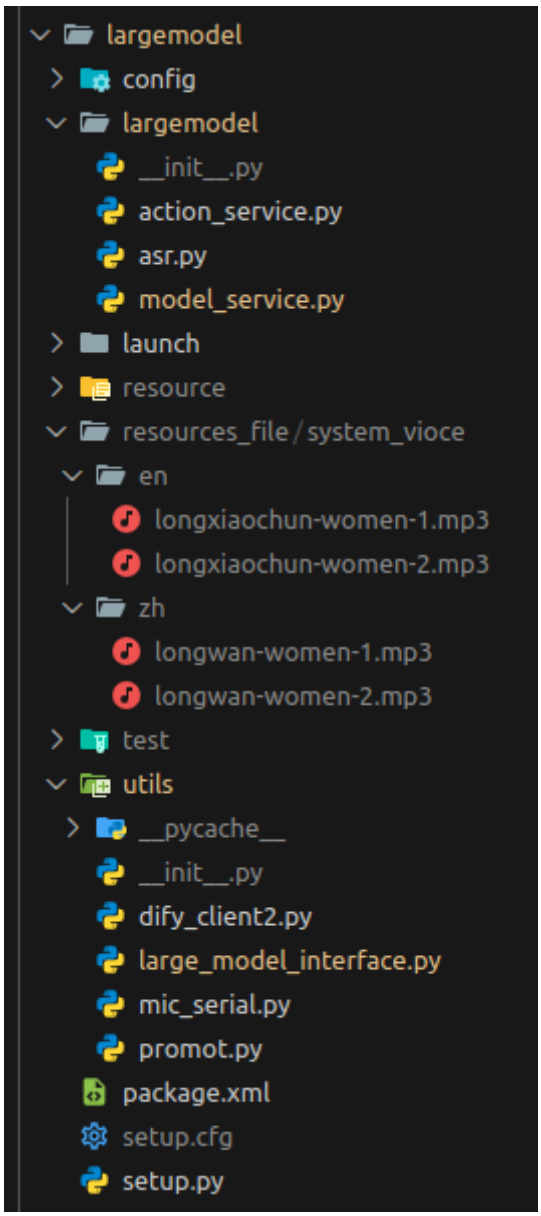
```
/home/jetson/LargeModel_ws/src/largemodel
```

Jetson Nano host:

Requires entering the Docker container first:

```
root/LargeModel_ws/src/largemodel
```

The function package file structure is as follows:



Description of folders and files:

2.1.1 config

Configuration folder, stores configuration files

- large_model_interface.yaml

Large model interface configuration file, used to configure API keys and large model parameters for various platforms.

- yahboom.yaml

Node configuration file: used to configure parameters for core nodes.

2.1.2 largemodel

Source code folder, core program for AI large model embodied intelligence gameplay

- asr.py

Speech recognition program file, used to run the speech recognition model and interact with the user.

- model_service.py

Model server program file, used to call various model interfaces to implement the model inference architecture.

- action_service.py

Action server program file, used to receive the action list requested by the model server, control the robot's movement and play sounds.

2.1.3 launch

Launch file folder, used to store ROS2 node launch files

- largemodel_control.launch.py

Launch file for AI large model embodied intelligence gameplay: starts multiple nodes, with two startup methods: voice interaction mode and text interaction mode.

2.1.4 resources_file

Stores audio files for system sounds.

2.1.5 utils

Component folder, stores program files for non-core functions

- large_model_interface.py

Large model interface program file, contains the underlying interfaces for calling large models from various platforms. The calling programs for different platforms and models are different, and the calling methods are uniformly managed in the interface file.

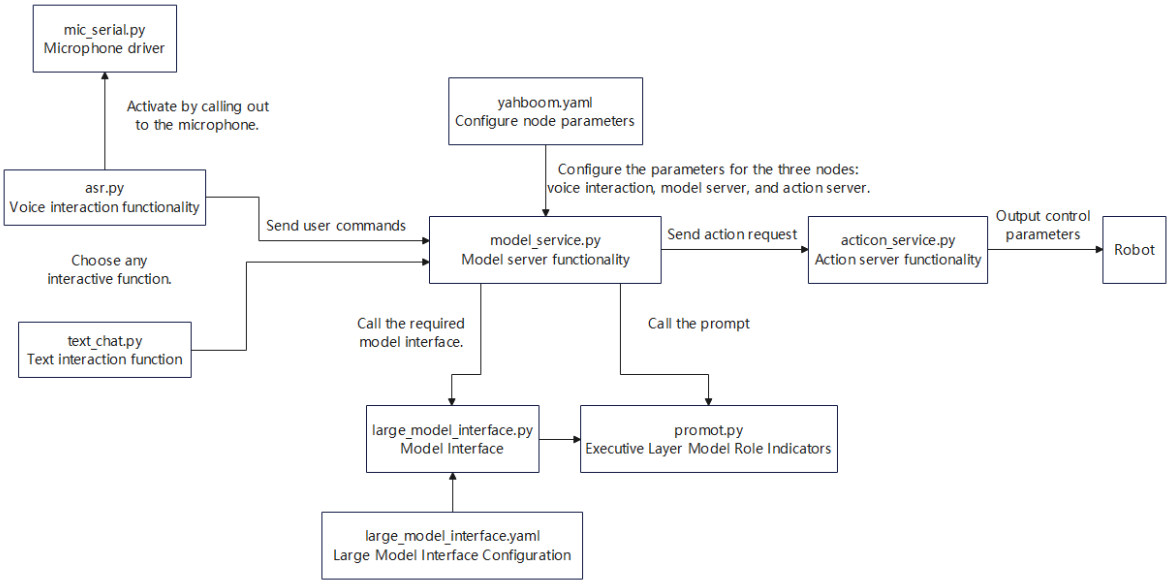
- mic_serial.py

Voice module driver program file, used to drive the wake-up word function of the voice module.

- promot.py Large language model prompt file: A file used to generate prompt words for the execution layer large language model.
- dify_client2.py

Dify API functions, used for requesting the local Dify application from the international version of Dify.

2.2 Inter-program Call Relationship Diagram



3. Speech Recognition Function

The speech recognition function includes two parts: VAD (Voice Activity Detection) and speech-to-text conversion. The source code path is:

Jetson Orin Nano, Jetson Orin NX host:

```
/home/jetson/LargeModel_ws/src/largemodel/largemodel/asr.py
```

Jetson Nano host:

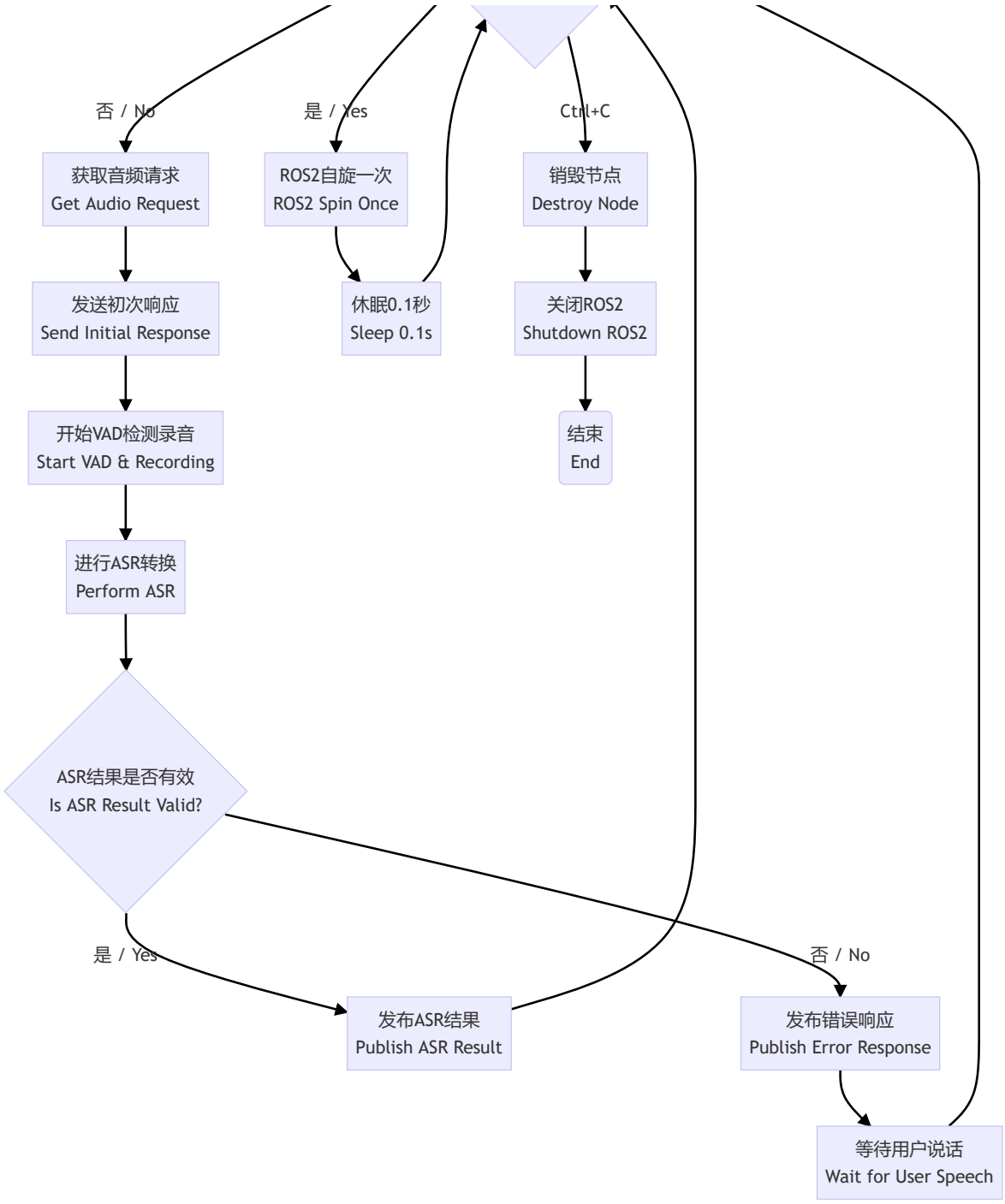
Requires entering the Docker container first:

```
root/LargeModel_ws/src/largemodel/largemodel/asr.py
```

3.1 Program Flowchart

asr program flowchart.


开始
Start
初始化ROS2节点
Initialize ROS2 Node
初始化参数配置
Initialize Parameters
初始化大模型接口
Initialize LLM Interface
初始化语音唤醒
Initialize Wake Word Detection
初始化ASR模型
Initialize ASR Model
初始化语言设置
Initialize Language Settings
初始化WebRTC VAD
Initialize WebRTC VAD
创建服务客户端和发布者
Create Service Clients and Publishers
打印初始化完成信息
Print Initialization Info
音频请求队列是否为空
Is Audio Request Queue Empty?


否 / No
是 / Yes
Ctrl+C
获取音频请求
Get Audio Request
ROS2自旋一次
ROS2 Spin Once
销毁节点
Destroy Node
发送初次响应
Send Initial Response
休眠0.1秒
Sleep 0.1s
关闭ROS2
Shutdown ROS2
开始VAD检测录音
Start VAD & Recording
结束
End
进行ASR转换
Perform ASR
ASR结果是否有效
Is ASR Result Valid?
是 / Yes
否 / No
发布ASR结果
Publish ASR Result
发布错误响应
Publish Error Response
等待用户说话
Wait for User Speech

3.2 VAD Voice Activity Detection

Implementation Program: The `listen_for_speech` method in the `ASRNode` class.

Program Description: The program uses a specified microphone to record audio in real time and uses VAD (Voice Activity Detection) to determine if someone is speaking. When a segment of speech is detected to have ended (continuous silence exceeding a set number of frames), recording stops and the valid speech content is saved to a file.

Detailed logic is as follows:

1. Initialize the audio stream and configure parameters (such as sampling rate, number of channels, etc.).
2. Continuously read audio frames and perform voice activity detection.
3. If speech is detected, add the audio frames to the buffer; if continuous silence exceeding the threshold (90 frames, approximately 1 second) is detected, end the recording.
4. After recording ends, remove the trailing silence and save the valid speech as a WAV file.
5. If no valid speech is detected, no file is saved.

```
  def listen_for_speech(self, mic_index=0):
        p = pyaudio.PyAudio()
        audio_buffer = []
        silence_counter = 0
        MAX_SILENCE_FRAMES = 90  # 30帧*30ms=900ms静音后停止 / Stop after 900ms of
silence (30 frames * 30ms)
        speaking = False  # 语音活动标志 / Flag indicating speech activity
        frame_counter = 0  # 计数器 / Frame counter
        stream_kwargs = {
            "format": pyaudio.paInt16,
            "channels": 1,
            "rate": self.sample_rate,
            "input": True,
            "frames_per_buffer": self.frame_bytes,
        }
        if mic_index != 0:
            stream_kwargs["input_device_index"] = mic_index

        # 通过蜂鸣器提示用户讲话 / Prompt the user to speak via the buzzer
        self.pub_beep.publish(UInt16(data=1))
        time.sleep(0.5)
        self.pub_beep.publish(UInt16(data=0))

        try:
            # 打开音频流 / Open audio stream
            stream = p.open(**stream_kwargs)
            while True:
                if self.stop_event.is_set():
                    return False

                frame = stream.read(
```

```
                    self.frame_bytes, exception_on_overflow=False
                )  # 读取音频数据 / Read audio data
                is_speech = self.vad.is_speech(
                    frame, self.sample_rate
                )  # VAD检测 / VAD detection

                if is_speech:
                    # 检测到语音活动 / Detected speech activity
                    speaking = True
                    audio_buffer.append(frame)
                    silence_counter = 0
                else:
                    if speaking:
                        # 在语音活动后检测静音 / Detect silence after speech
activity
                        silence_counter += 1
                        audio_buffer.append(
                            frame
                        )  # 持续记录缓冲 / Continue recording buffer

                        # 静音持续时间达标时结束录音 / End recording when silence
duration meets the threshold
                        if silence_counter >= MAX_SILENCE_FRAMES:
                            break
                frame_counter += 1
                if frame_counter % 2 == 0:
                    self.get_logger().info("1" if is_speech else "-")
                    # print('1-' if is_speech else '0-', end='', flush=True)  #
实时状态显示方式 / Real-time status display
        finally:
            stream.stop_stream()
            stream.close()
            p.terminate()

        # 保存有效录音（去除尾部静音） / Save valid recording (remove trailing
silence)
        if speaking and len(audio_buffer) > 0:
            # 裁剪最后静音部分 / Trim the last silent part
            clean_buffer = (
                audio_buffer[:-MAX_SILENCE_FRAMES]
                if len(audio_buffer) > MAX_SILENCE_FRAMES
                else audio_buffer
            )

            with wave.open(self.user_speechdir, "wb") as wf:
                wf.setnchannels(1)
                wf.setsampwidth(p.get_sample_size(pyaudio.paInt16))
                wf.setframerate(self.sample_rate)
                wf.writeframes(b"".join(clean_buffer))
                return True
```

3.3 ASR Speech Recognition

Implementation: The ASR_conversion method in the ASRNode class converts the audio file into text.

It calls the speech recognition model interface function in the large_model_interface.py file.

Note: Text recognized as having fewer than 4 characters will be considered invalid. This is to prevent misrecognized content from being treated as valid.

Program Explanation:

1. If using online_asr, the corresponding method is called, and the result is checked to see if it is valid text (length greater than 4). If successful, the recognized content is returned; otherwise, an error is logged, and 'error' is returned.
2. Otherwise, SenseVoiceSmall_ASR is used for recognition, and the same result judgment and processing are performed.

Note that SenseVoiceSmall_ASR is a local model speech recognition method and can only be used on Jetson Orin Nano and Jetson Orin NX hosts.

```
def ASR_conversion(self, input_file):
    if self.use_oline_asr:
        result=self.modelinterface.oline_asr(input_file)
        if result[0] == 'ok' and len(result[1]) > 4:
            return result[1]
        else:
            self.get_logger().error(f'ASR Error:{result[1]}')
            return 'error'
    else:
        result=self.modelinterface.SenseVoiceSmall_ASR(input_file)
        if result[0] == 'ok' and len(result[1]) > 4:
            return result[1]
        else:
            self.get_logger().error(f'ASR Error:{result[1]}')
            return 'error'
```

4. Model Server Functionality

The program is implemented in `model_service.py`, which receives speech recognition results in voice interaction mode or terminal input in text interaction mode, and implements the large language model inference logic. The source code path is:

Jetson Orin Nano, Jetson Orin NX host:

```
/home/jetson/LargeModel_ws/src/largemodel/largemodel/model_service.py
```

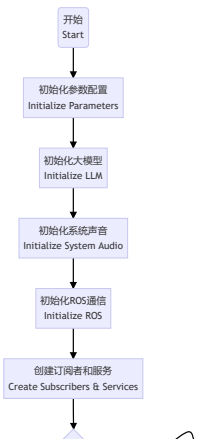
Jetson Nano host:

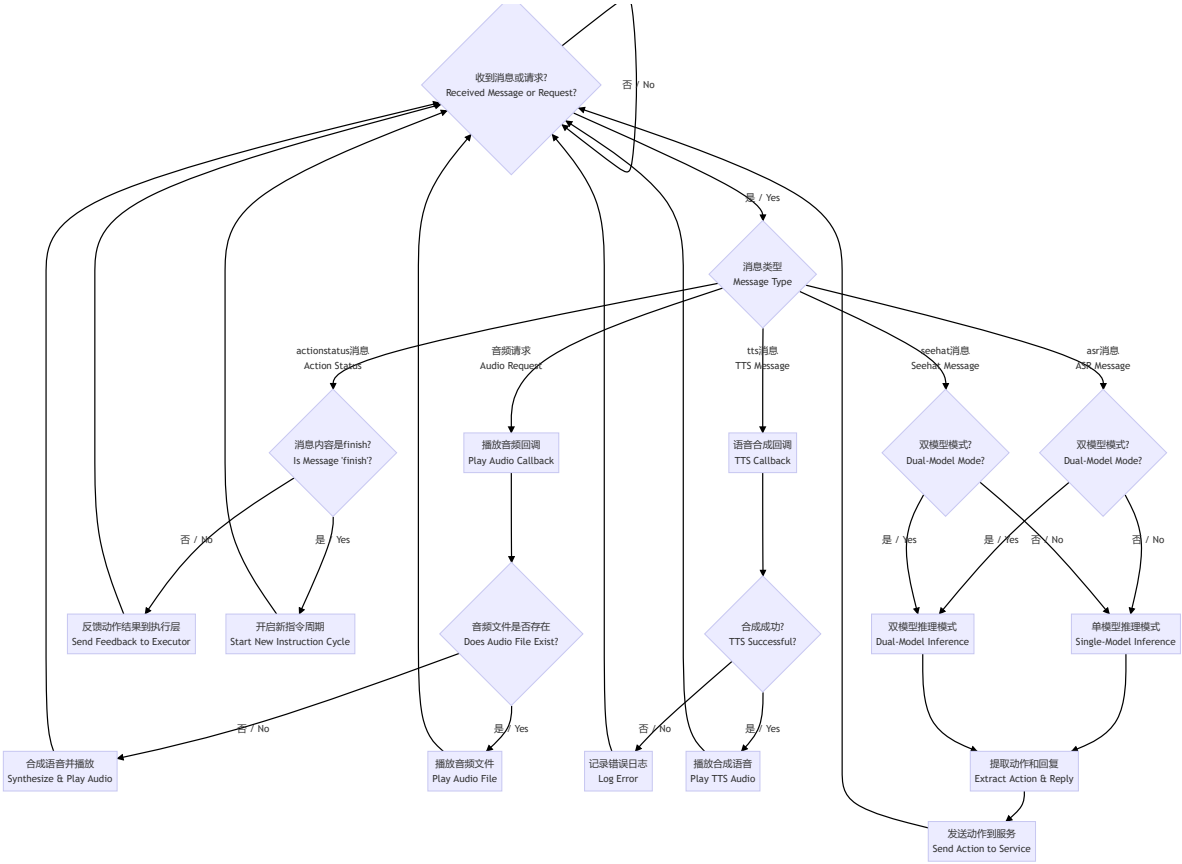
Requires entering the Docker container first:

```
root/LargeModel_ws/src/largemodel/largemodel/model_service.py
```

4.1 Program Flowchart

model_service program flowchart




收到消息或请求?
Received Message or Request?
否 / No
是 / Yes
消息类型
Message Type
actionstatus消息
Action Status
音频请求
Audio Request
tts消息
TTS Message
seehat消息
Seehat Message
asr消息
ASR Message
消息内容是finish?
Is Message 'finish'?
播放音频回调
Play Audio Callback
语音合成回调
TTS Callback
双模型模式?
Dual-Model Mode?
双模型模式?
Dual-Model Mode?
否 / No
是 / Yes
是 / Yes
是 / Yes
否 / No
否 / No
反馈动作结果到执行层
Send Feedback to Executor
开启新指令周期
Start New Instruction Cycle
音频文件是否存在
Does Audio File Exist?
合成成功?
TTS Successful?
双模型推理模式
Dual-Model Inference
单模型推理模式
Single-Model Inference
否 / No
是 / Yes
否 / No
是 / Yes
合成语音并播放
Synthesize & Play Audio
播放音频文件
Play Audio File
记录错误日志
Log Error
播放合成语音
Play TTS Audio
提取动作和回复
Extract Action & Reply
发送动作到服务
Send Action to Service

4.2 Dual Model Inference (Domestic Version)

The dual model inference mode is used by default. The implementation is in the `dual_large_model_mode` and `instruction_process` methods of the `LargeModelService` class.

Program interpretation:

1. If it's a new instruction cycle (self.new_order_cycle is True):

- Initialize the multimodal historical context;
- Use the task decision model to plan the task based on the user input prompt;
- Pass the planning result to the instruction execution layer model for processing;
- Set new_order_cycle to False, indicating that the current instruction cycle has started execution.

2. Otherwise (not a new cycle):

- Directly pass the input prompt and type to the instruction execution layer model for processing.

```
def dual_large_model_mode(self, type, prompt=""):
    """
    此函数实现了双模型推理模式，即先由文本生成模型进行任务规划，然后由多模态大模型生成动作列表
    This function implements the dual model inference mode, where the text
generation model first plans the task, and then the multimodal large model
generates the action list.
    """
    if (
        self.new_order_cycle
    ):  # 判断是否是新任务周期 / Determine if it is a new task cycle
        # 判断上一轮对话指令是否完成如果完成就清空历史上下文，开启新的上下文 / Determine if
the previous round of dialogue instructions are completed. If completed, clear
the historical context and start a new context
        self.model_client.init_Multimodal_history(
            get_prompt()
        )  # 初始化执行层上下文历史 / Initialize execution layer context history
        execute_instructions = self.model_client.TaskDecision(
            prompt
        )  # 调用决策层大模型进行任务规划 / Call the decision layer large model for
task planning

        if not execute_instructions == "error":
            if self.text_chat_mode:
                msg = String(
                    data=f"The upcoming task to be carried out：
{execute_instructions}"
                )
```

```
                self.text_pub.publish(msg)
            else:
                self.get_logger().info(
                    f"The upcoming task to be carried out：
{execute_instructions}"
                ) # Tasks to be performed: ...
            self.instruction_process(
                type="text",
                prompt=f"用户：{prompt},决策层AI规划:{execute_instructions}",
            )  # 传递决策层模型规划好的执行步骤给执行层模型 / Pass the planned execution
steps from the decision layer model to the execution layer model
            self.new_order_cycle = (
                False  # 重置指令周期标志位 / Reset the instruction cycle flag
            )
        else:
            self.get_logger().info(
                "The model service is abnormal. Check the large model account or
configuration options"
            ) # Model inference failed. Please check your model quota and
account status!
    else:
        self.instruction_process(
            prompt, type
        )  # 调用执行层大模型生成成动作列表并执行 / Call the execution layer large
model to generate an action list and execute

def instruction_process(self, prompt, type, conversation_id=None):
    """
    根据输入信息的类型（文字/图片），构建不同的请求体进行推理，并返回结果）
    Based on the type of input information (text/image), construct different
request bodies for inference and return the result.
    """
    if self.regional_setting == "China": # Domestic version
        if type == "text":
            raw_content = self.model_client.multimodalinfer(prompt)
        elif type == "image":
            self.save_single_image()
            raw_content = self.model_client.multimodalinfer(
                "机器人反馈:执行seewhat()完成", image_path=self.image_save_path
            )
        json_str = self.extract_json_content(raw_content)

    elif self.regional_setting == "international":  # International Version
        if type == "text":
            result = self.model_client.TaskExecution(
                input=prompt,
                map_mapping=self.map_mapping,
                language=self.language_dict[self.language],
                conversation_id=conversation_id,
            )
            if result[0]:
                json_str = self.extract_json_content(result[1])
                self.conversation_id = result[2]
            else:
                self.get_logger().info(f"ERROR:{result[1]}")
        elif type == "image":
            self.save_single_image()
            result = self.model_client.TaskExecution(
```

```
                input="机器人反馈:执行seewhat()完成",
                map_mapping=self.map_mapping,
                language=self.language_dict[self.language],
                image_path=self.image_save_path,
                conversation_id=conversation_id,
            )
            if result[0]:
                json_str = self.extract_json_content(result[1])
                self.conversation_id = result[2]
            else:
                self.get_logger().info(f"ERROR:{result[1]}")

    if json_str is not None:
        # 解析JSON字符串,分离"action"、"response"字段 / Parse JSON string, separate
"action" and "response" fields
        action_plan_json = json.loads(json_str)
        action_list = action_plan_json.get("action", [])
        llm_response = action_plan_json.get("response", "")
    else:
        self.get_logger().info(
            f"LargeScaleModel return: {json_str},The format was unexpected. The
output format of the AI model at the execution layer did not meet the
requirements"
        )
        return

    if self.text_chat_mode:
        msg = String(data=f'"action": {action_list}, "response":
{llm_response}')
        self.text_pub.publish(msg)
    else:
        self.get_logger().info(
            f'"action": {action_list}, "response": {llm_response}'
        )

    self.send_action_service(
        action_list, llm_response
    )  # 异步发送动作列表、回复内容给ActionServer / Asynchronously send action list
and response content to ActionServer
```

4.3 Dual-Model Inference (International Version)

7. The program implementation logic is the same as the domestic version, the difference being that the international version requests the local Dify application, which then requests the cloud-based large language model.

```
def dual_large_model_international_model(self, type, prompt=""):
    """
    This function is applicable to the international version of the dual-model
inference mode, using Dify as middleware.
    """
    if (
        self.new_order_cycle
    ):  # 判断是否是新任务周期 / Determine if it is a new task cycle
        self.conversation_id = None
```

```
            result = self.model_client.TaskDecision(prompt)
            if result[0]:
                if self.text_chat_mode:  # 文字交互模式 / Text interaction mode
                    msg = String(
                        data=f"The upcoming task to be carried out:{result[1]}"
                    )
                    self.text_pub.publish(msg)
                else:  # 语音交互模式 / Voice interaction mode
                    self.get_logger().info(
                        f"The upcoming task to be carried out:{result[1]}"
                    )

                self.instruction_process(
                    type="text", prompt=f"用户：{prompt},决策层AI规划:{result[1]}"
                )
                self.new_order_cycle = (
                    False  # 重置指令周期标志位 / Reset the instruction cycle flag
                )
            else:
                self.get_logger().info(f"ERROR: {result[1]}")

        else:
            self.instruction_process(
                prompt, type, conversation_id=self.conversation_id
            )  # 调用执行层大模型生成成动作列表并执行 / Call the execution layer large
model to generate an action list and execute
```

5. Action Server Functionality

The program implementing this functionality is action_service.py, which receives the list of actions requested by the model server, parses the action list, and executes them. Source code path:

Jetson Orin Nano, Jetson Orin NX host:

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

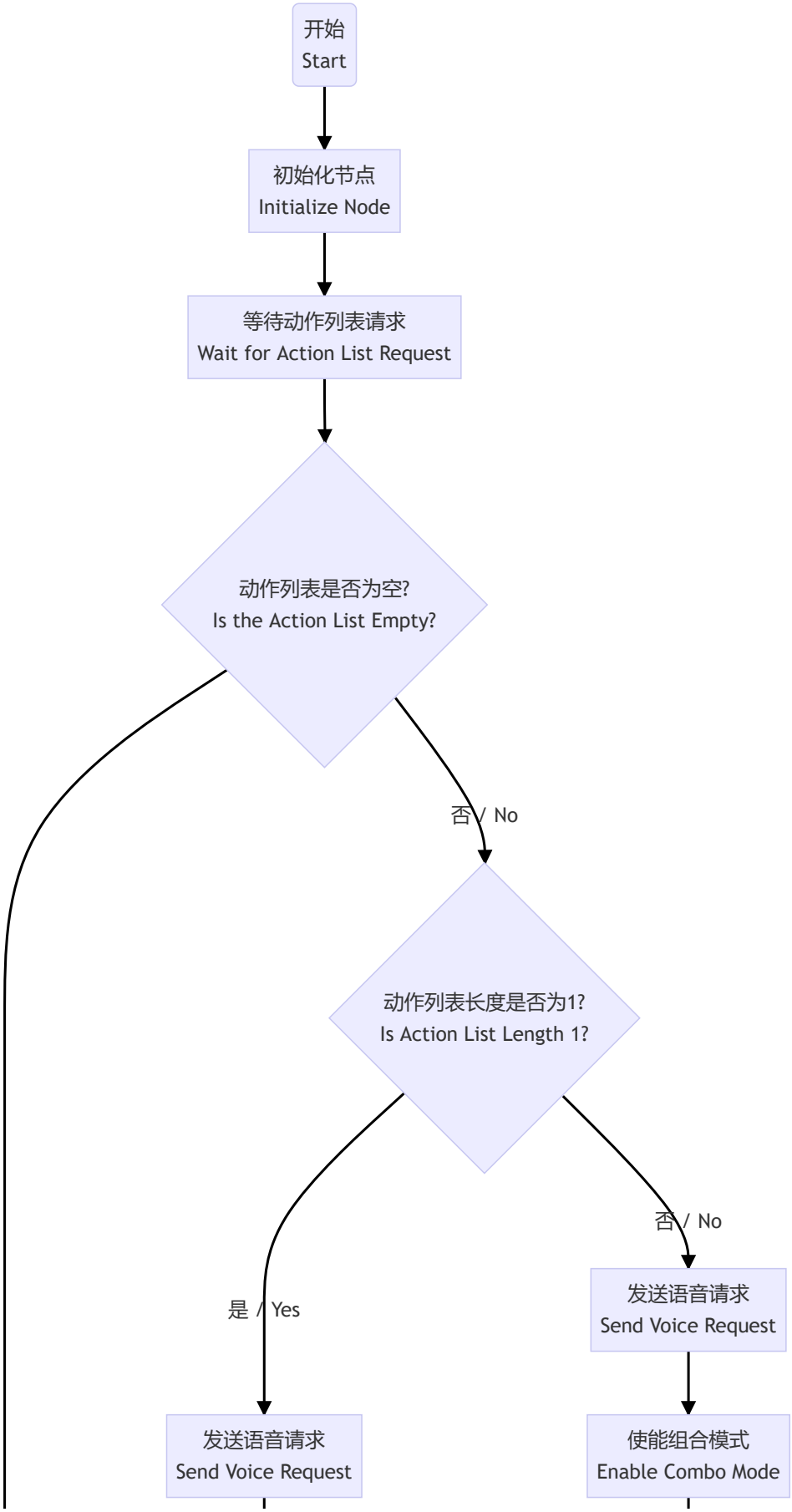
Jetson Nano host:

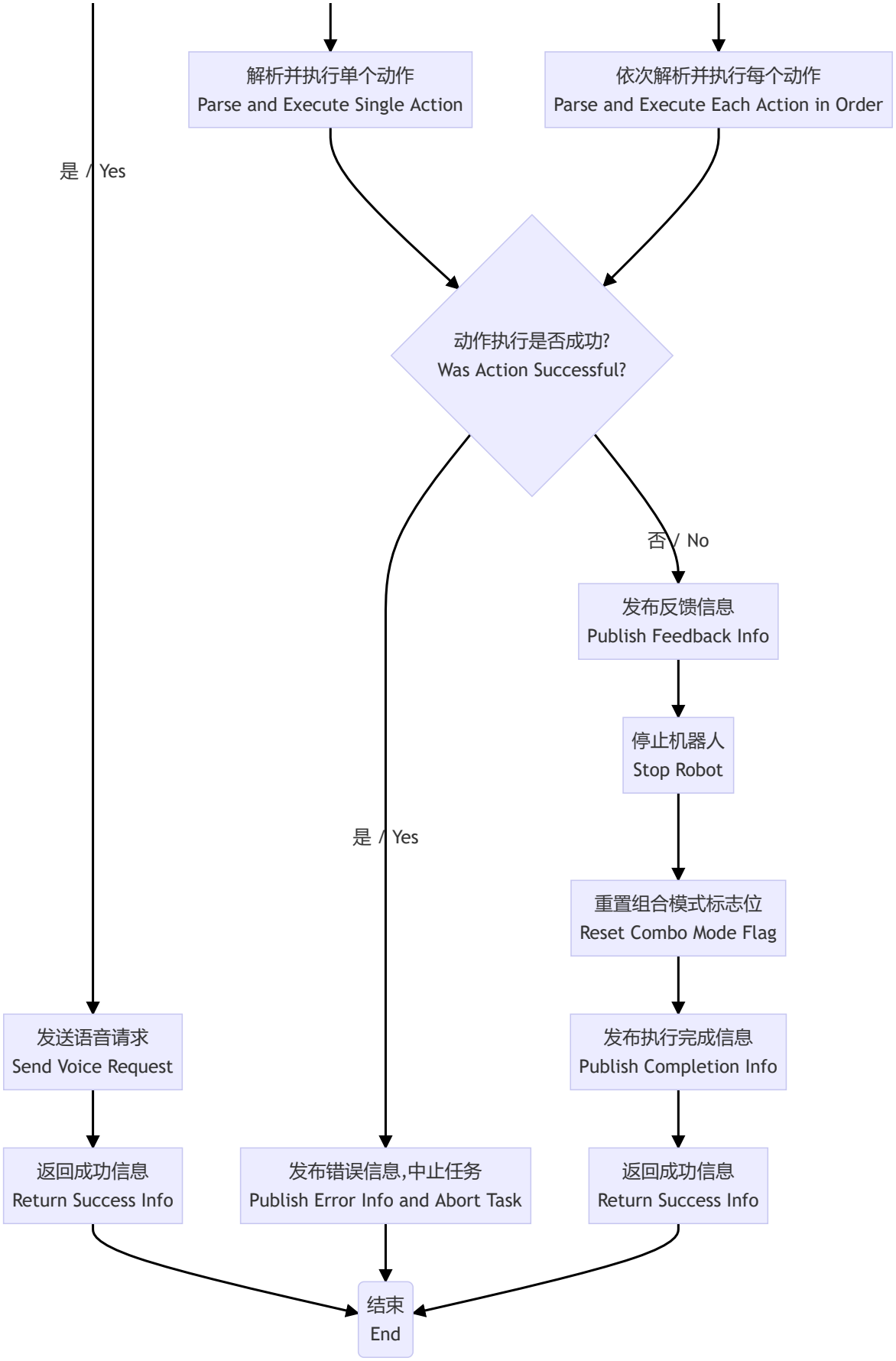
Requires entering the Docker container first:

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

5.1 Program Flowchart

Saction_service program flowchart


开始
Start
初始化节点
Initialize Node
等待动作列表请求
Wait for Action List Request
动作列表是否为空?
Is the Action List Empty?
否 / No
动作列表长度是否为1?
Is Action List Length 1?
是 / Yes
否 / No
发送语音请求
Send Voice Request
使能组合模式
Enable Combo Mode
发送语音请求
Send Voice Request


解析并执行单个动作
Parse and Execute Single Action
依次解析并执行每个动作
Parse and Execute Each Action in Order
是 / Yes
动作执行是否成功?
Was Action Successful?
否 / No
发布反馈信息
Publish Feedback Info
停止机器人
Stop Robot
是 / Yes
重置组合模式标志位
Reset Combo Mode Flag
发送语音请求
Send Voice Request
发布执行完成信息
Publish Completion Info
返回成功信息
Return Success Info
发布错误信息,中止任务
Publish Error Info and Abort Task
返回成功信息
Return Success Info
结束
End

5.2 Action Function Library

The robot's action functions come from the methods in the CustomActionServer class, which includes functions for various sub-actions. This section uses the function for controlling the robotic arm to move upwards as an example; other action functions will be explained when they first appear in subsequent chapters.

Program explanation:

1. Convert the input string parameter to a floating-point number.
2. Directly call the function, passing the parameter, and communicate with the underlying driver board to control the six servos.
3. Determine whether to publish the completion message based on the mode.

```
def arm_up(self):  # Robotic arm moves upward
    # Call the function to communicate directly with the underlying driver board
and control the six servos to extend upwards.
    Arm.Arm_serial_servo_write6(90,90,90,90,90,90,1000)
    #If it's not in combination mode and the process hasn't been interrupted,
publish the message that the robotic arm has completed its upward movement.
    if not self.combination_mode and not self.interrupt_flag:
        self.action_status_pub("arm_up_done")
```

5.3 Parsing the Action List to Control Robot Functionality

This section describes parsing the action list generated by the large language model into functions that control the robot entity, and then executing them. The implementation is found in the `execute_callback` method of the `CustomActionServer` class.

Program Description:

1. Receives the action list (in string format) sent by the client;
2. If the action list is empty, return a success result directly;
3. If there is only one action, parse and execute the corresponding method; if it fails, terminate the process;
4. If there are multiple actions, enter a combined mode to execute them sequentially, recording logs and providing feedback during the process;
5. After all actions are completed, call `stop()` to stop the robot;
6. Finally, return the successful execution result to the client.

```
def execute_callback(self, goal_handle):
    feedback_msg = Rot.Feedback()
    stop = getattr(self, "stop")  # Get the stop method, which stops the robot's
movement by publishing a topic.
    actions=goal_handle.request.actions
    if not actions: # If the action list is empty, return success directly.
```

```
        if not self.text_chat_mode:
           self.send_Audiorequest(goal_handle.request.llm_response)

        if self.use_double_llm:
            self.action_status_pub('机器人反馈：回复用户完成')

        goal_handle.succeed()
        result = Rot.Result()
        result.success = True
        return result
    elif len(actions) == 1:# The action list contains only one action; the
normal execution flow will be followed.
        # Case 2: The list has only one element
        action = actions[0]
        if not self.text_chat_mode:
           self.send_Audiorequest(goal_handle.request.llm_response)

        match = re.match(r"(\w+)\((.*)\)", action)
        if not match:
            self.get_logger().warning(f'action_service: {action} is invalid
action,skip execution')
            goal_handle.abort()
            result = Rot.Result()
            result.success = False
            return result
        else:
            action_name, args_str = match.groups()
            args = [arg.strip() for arg in args_str.split(",")] if args_str else
[]
            try:
                if hasattr(self, action_name):
                    method = getattr(self, action_name)
                    method(*args)
                    feedback_msg.status = f'action service execute  {action}
successed'
                    # self.get_logger().info(feedback_msg.status)  # Add logging
                    goal_handle.publish_feedback(feedback_msg)
                else:
                    self.get_logger().warning(f'action_service:inviald:
{action_name},skip execution')
                    self.action_status_pub('机器人反馈:动作函数不存在，无法执行')
                    goal_handle.abort()
                    result = Rot.Result()
                    result.success = False
                    return result
            except Exception as e:
                self.get_logger().error(f'action_service:execute action:
{action} failed,error-log: {str(e)}')
                goal_handle.abort()
                result = Rot.Result()
                result.success = False
                return result
    else:#If the action list contains multiple actions, enable combination mode.
        if not self.text_chat_mode:
           self.send_Audiorequest(goal_handle.request.llm_response)

        self.combination_mode=True
        for action in actions:
```

```
            # Using regular expressions to parse action names and parameters
            match = re.match(r"(\w+)\((.*)\)", action)
            if not match:
                self.get_logger().warning(f'action_service: {action} is invalid
action, skip execution')
                continue

            action_name, args_str = match.groups()
            args = [arg.strip() for arg in args_str.split(",")] if args_str else
[]

            try:

                # Check if the action is a method of the CustomActionServer
class
                if hasattr(self, action_name):
                    method = getattr(self, action_name)
                    # Dynamically call a method and pass parameters
                    method(*args)
                    # method(*converted_args)
                    feedback_msg.status = f'action service execute  {action}
successed'
                    self.get_logger().info(feedback_msg.status)  # Add logging
                    goal_handle.publish_feedback(feedback_msg)
                else:
                    self.get_logger().warning(f'action_service:inviald:
{action_name}, skip execution')
            except Exception as e:
                self.get_logger().error(f'action_service:execute action:
{action} failed,error-log: {str(e)}')
                goal_handle.abort()
                result = Rot.Result()
                result.success = False
                return result

        self.action_status_pub(f'机器人反馈：执行{actions}完成')
        self.combination_mode=False#Reset the combination mode flag
    stop()  # Stop the robot after completing all actions.
   # Return success message to the client
    goal_handle.succeed()
    result = Rot.Result()
    result.success = True
    return result
```

6. Interruption Function

The robot supports interruptions at any stage, which can be divided into recording stage interruptions, dialogue stage interruptions, and action stage interruptions. This section introduces the principles of interruption at each stage.

6.1 Recording Stage Interruption

If you make a mistake during recording, or are dissatisfied with the recorded content and need to re-record, you can interrupt the previous recording and start speaking and recording again by re-activating the robot **during the recording process**.

- The logic is implemented in the **main_loop** method of the **ASRNode** class in the asr.py file:

- Each time the robot is activated, if there is already a running thread for recording, it is interrupted via the thread event `stop_event`, and waits for its termination;
- After clearing the stop event flag, a new recording thread is started.

```
def main_loop(self):
    while rclpy.ok():
        while (
            self.audio_request_queue.qsize() > 1
        ):  # 只处理最近的一次唤醒请求，防止重复唤醒 / Process only the most recent
wake-up request to prevent duplicates
            self.audio_request_queue.get()

        if not self.audio_request_queue.empty():
            self.audio_request_queue.get()
            self.wakeup_pub.publish(
                Bool(data=True)
            )  # 发布唤醒信号 / Publish wake-up signal
            self.get_logger().info("I'm here")
            playsound(
                self.audio_dict[self.first_response]
            )  # 应答用户 / Respond to the user

            if (
                self.current_thread and self.current_thread.is_alive()
            ):  # 打断上次的唤醒处理线程 / Interrupt the previous wake-up handling
thread
                self.stop_event.set()
                self.current_thread.join()  # 等待当前线程结束 / Wait for the
current thread to finish
                self.stop_event.clear()  # 清除事件 / Clear the event
            self.current_thread = threading.Thread(target=self.kws_handler)
            self.current_thread.daemon = True
            self.current_thread.start()
        rclpy.spin_once(self, timeout_sec=0.1)
        time.sleep(0.1)
```

6.2 Interrupting the Dialogue Phase

If you are dissatisfied with the robot's response during its speech or don't want the robot to continue speaking, you can use the wake word to interrupt the robot's speech and start recording your voice. At this point, you can give the robot a new command (still within the current task cycle), or you can say "End current task" to directly end the current task and start a new task cycle.

- The logic is implemented in the **wakeup_callback** and **play_audio** methods of the **CustomActionServer** class in the action_service.py file:
- wakeup_callback is the callback function for wake-up processing. In the asr.py program, each time a wake-up signal is detected, it publishes a wake-up signal via topic communication. wakeup_callback subscribes to and processes this signal.
- Each time a wake-up occurs, it checks whether **pygame.mixer** is currently playing audio. If so, it notifies the playback thread to stop playback via the thread event self.stop_event.
- If a previous action is detected to be running after the wake-up, the **self.interrupt_flag** flag is set, which is used for subsequent action interruption.

```
def wakeup_callback(self, msg):
    if msg.data:
        if pygame.mixer.music.get_busy():
            self.stop_event.set()
        if self.action_runing:
            self.interrupt_flag = True
            self.stop()
            self.pubSix_Arm(self.init_joints)
```

When playing audio, the system checks if `self.stop_event` has been set. If it detects that it has been set, it immediately stops the currently playing audio.

```
def play_audio(self, file_path: str, feedback: Bool = False) -> None:
    """
    同步方式播放音频函数The function for playing audio in synchronous mode
    """
    pygame.mixer.music.load(file_path)
    pygame.mixer.music.play()
    while pygame.mixer.music.get_busy():
        if self.stop_event.is_set():
            pygame.mixer.music.stop()
            self.stop_event.clear()  # Clear events
            return
        pygame.time.Clock().tick(10)
    if feedback:
        self.action_status_pub("机器人反馈：回复用户完成")
```

6.3 Action Phase Interruption

If the robot is interrupted during the execution of an action, it will stop the current action and return to its initial posture.

For example, actions such as robotic arm grasping and sorting require launching external programs in a subprocess. Here, we use the color block handling function `change_pose` as an example:

While the color block handling is not complete, the program will continuously wait in the `while not self.change_pose_future.done():` loop. During this process, if the `self.interrupt_flag` interrupt flag is detected as set, the `check_close_change_pose` function will be called to recursively terminate the subprocess tree, then the robotic arm will be controlled to return to the grasping posture, and the task will be terminated.

```
def change_pose(self, x1, y1, x2, y2,x3,y3,x4,y4,src,tar,side):
    src_color = src.strip("'\"") # Remove single and double quotes
    self.cur_down_name = src_color
    self.cur_down_pose[self.cur_down_name] = []
    cmd1 = "ros2 run largemodel_arm Get_Target_Pose_KCF"
    subprocess.Popen(
        [
            "gnome-terminal",
            "--title=grasp_desktop",
            "--",
            "bash",
```

```
            "-c",
            f"{cmd1}; exec bash",
        ]
    )
    time.sleep(3.0)
    x1 = int(x1)
    y1 = int(y1)
    x2 = int(x2)
    y2 = int(y2)
    x3 = int(x3)
    y3 = int(y3)
    x4 = int(x4)
    y4 = int(y4)
    side = int(side)
    time.sleep(5.0)
    self.object_position_pub.publish(Int16MultiArray(data=[x1, y1, x2,
y2,x3,y3,x4,y4,side]))

    while not self.change_pose_future.done():
        if self.interrupt_flag:
            self.check_close_change_pose()
            Arm.Arm_serial_servo_write6(90,150,12,20,90,30,1000)
            return
        time.sleep(0.1)
```