# Software Lecture 5:

# ROS Actions

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# Contents

In this lecture, we shall cover:

- Overview for ROS Actions
- Defining a new ROS Action
- Brief introduction to Object-Oriented Programming
- Creating our first ROS Action Client/Server pair
- Brief introduction to launch files

# Before We Begin

- Again, I strongly suggest bookmarking the following link: [https://github.com/OxRAMSociety/RobotArm](https://github.com/OxRAMSociety/RobotArm)

- All example code can be found in:

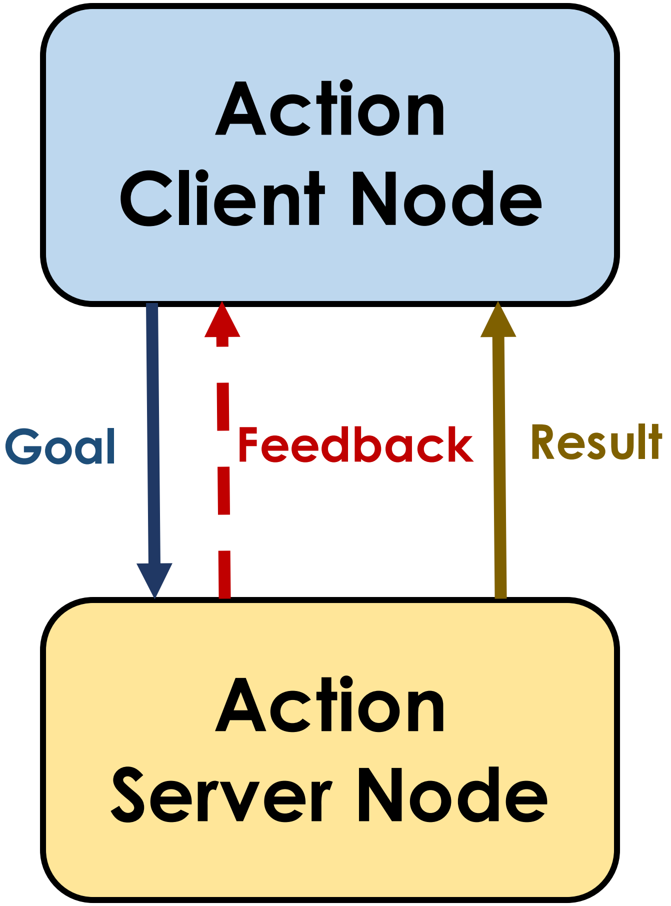
Tutorials/Software Tutorials (2022)/Example Scripts

*Of course, code for this lecture will be in the Lecture 5 folder, and so on for future lectures*

- I will highlight some code in these presentations, but you should refer to the Example Scripts for the entire code

# ROS Actions – Overview

- Request/response system, with feedback!
- Client node sends a goal and awaits a result
- Server node listens to the goal, processes it (while providing feedback) and sends a result back to that client when (eventually) complete
- Much better suited for processes that take an extended period of time (for which feedback would be useful)



# Creating an Action Client/Server Pair

- Consider some abstract action that we may want to request
- For this example:
  - We shall specify for how many seconds that action should be carried out in our goal
  - We also desire feedback telling us the number of seconds for which the action has been carried out
  - Finally, we want to receive a result that tells us whether the action was completed successfully

# Defining a new ROS Action

- ROS actions must be defined in a unique 'action' file
- **Navigate to tutorial_scripts and create a folder named action**
  - This folder will contain all our custom ROS action definitions
- **Inside that folder, create a file Example.action and open it**

*I didn't call it ExampleAction.action for a reason that will become apparent later...*

# Defining a new ROS Action

- We first define all data contained within the goal message
  - Same as for ROS Services
- We then define all data contained within the result message
- Finally, we define all data contained within the feedback message
- We separate these three groups with 3 hyphens (i.e. ---)

```
# Goal
int32 seconds_requested

---
# Result
bool success

---
# Feedback
int32 seconds_elapsed
```

**Reproduce this!**

# Defining a new ROS Action

- For us to be able to use our new action, we must first enable functionality for ROS actions in our package
- **Navigate to tutorial_scripts and open the CMakeLists.txt file**
- **Go to line ~10 and uncomment/edit the find_package section as follows:**

```
10  find_package(catkin REQUIRED COMPONENTS
11    rospy
12    std_msgs
13    message_generation
14    actionlib_msgs
15  )
```

# Defining a new ROS Action

- **Go to line ~60 and uncomment/edit the add_action_files and generate_messages sections as follows:**

```
63  ## Generate actions in the 'action' folder
64  add_action_files(
65    FILES
66    Example.action
67  )
68
69  ## Generate added messages and services with any dependencies listed here
70  generate_messages(
71    DEPENDENCIES
72    std_msgs
73    actionlib_msgs
74  )
```

# Defining a new ROS Action

- **Go to line ~100 and uncomment/edit the catkin_package section as follows:**

```
105  catkin_package(
106  #  INCLUDE_DIRS include
107    LIBRARIES tutorial_scripts
108    CATKIN_DEPENDS rospy std_msgs actionlib_msgs
109  #  DEPENDS system_lib
110    DEPENDS message_runtime
111  )
```

# Defining a new ROS Action

- **Now open the package.xml file, go to line ~58 and add/edit the following (note: we have already added the first two lines):**

```xml
<build_depend>message_generation</build_depend>
<exec_depend>message_runtime</exec_depend>

<build_depend>actionlib_msgs</build_depend>
<build_export_depend>actionlib_msgs</build_export_depend>
<exec_depend>actionlib_msgs</exec_depend>
```

- **Finally, save all files and rebuild the workspace**

# Creating an Action Server Node

- **In tutorial_scripts' scripts folder, create the file Example_Action_Server.py**
- From now on, these scripts will be too large to display in their entirety on these slides
- Therefore, find at them in the GitHub repository while following along to these lectures
- I will continue to highlight and explain key points

# An Aside – Object-Oriented Programming

- You will see that our action server is implemented as an object
- Objects are complex data structures with their own internal data and methods
- Classes are the blueprints for these objects, and define these data and methods
- This is the basis for Object-Oriented Programming (OOP), a very popular and intuitive programming paradigm

# Creating an Action Server Node

- The initialiser function automatically runs once when the object is first created
  - In this case, we use it to declare a new action server and start it up

```
# This function is run when the constructor for the class is called, and is used to initialise a new object of that class
def __init__(self):

    # Declare an action server, called 'example_as', of type ExampleAction, using function execute_cb to handle requests
    self.a_server = actionlib.SimpleActionServer("example_as", ExampleAction, execute_cb=self.execute_cb, auto_start=False)
    # Start the action server
    self.a_server.start()
```

# Creating an Action Server Node

- We also define a callback function to handle goals from action clients

```python
# This function is used to handle goals requested by an action client
def execute_cb(self, goal):

    feedback = ExampleFeedback()    # Instantiate feedback variable (of type ExampleFeedback)
    result = ExampleResult()    # Instantiate result variable (of type ExampleResult)
    result.success = True
    rate = rospy.Rate(1)

    rospy.loginfo("Action Request Received (%s) - Performing Action...",goal)

    for i in range(0, goal.seconds_requested):
        # Check whether the client has cancelled the request
        if self.a_server.is_preempt_requested():
            self.a_server.set_preempted()
            result.success = False
            break

        feedback.seconds_elapsed = i
        self.a_server.publish_feedback(feedback)    # Return feedback to the client
        rate.sleep()
        i += 1

    if result.success:  # Action successful
        feedback.seconds_elapsed += 1
        rospy.loginfo("SUCCESS - Action Complete after %s seconds \n ---",feedback.seconds_elapsed)
        self.a_server.set_succeeded(result) # Return the result (success) to the client
    else:   # Action failed (e.g. cancelled by client)
        rospy.logerr("FAILURE - Action Aborted!")
        self.a_server.set_aborted(result)   # Return the result (failure) to the client
```

# Creating an Action Server Node

- Finally, we need a main function that executes when the program is executed
  - In this case, it sets up the program as a ROS node, instantiates our action server as an object, and keeps the node running

```
if __name__ == "__main__":
    rospy.init_node("example_action_server_node")
    # Call the constructor for our class, instantiating it as object 's'
    s = ExampleActionServer()
    rospy.spin()
```

# Creating an Action Client Node

- **In tutorial_scripts' scripts folder, create the file Example_Action_Client.py**
- The first function we define is for handling feedback received from the action server
- This will execute even while the client waits for a result; in this way, the client can dynamically respond to feedback from the server

```
# Feedback from the action server is handled by this function
def feedback_cb(msg):
    rospy.loginfo("Feedback Received: %s", msg)
```

# Creating an Action Client Node

- We then define the function used to call the action server and return the result:

```python
# This function is run to call the action server
def call_server():

    # Declare an action client for action 'example_as' of type ExampleAction
    client = actionlib.SimpleActionClient('example_as', ExampleAction)

    # Wait for the corresponding action server to become available
    client.wait_for_server()

    # Instantiate a goal of type ExampleGoal
    goal = ExampleGoal()
    goal.seconds_requested = int(input("For how many seconds should I perform the action? (1<=t<=9): "))
    if goal.seconds_requested < 1:
        goal.seconds_requested = 1
    elif goal.seconds_requested > 9:
        goal.seconds_requested = 9

    # Send the goal to the action server, using the function feedback_cb to handle feedback
    client.send_goal(goal, feedback_cb=feedback_cb)

    # Wait for the result
    client.wait_for_result()

    # Retrieve the result once it is available
    result = client.get_result()

    return result
```

# Creating an Action Client Node

- Finally, we need a main function that executes when the program is executed
  - In this case, it sets up the program as a ROS node, and then calls the action server

```
if __name__ == '__main__':

    try:
        rospy.init_node('example_action_client_node')
        result = call_server()
        rospy.loginfo("Result Received: %s", result)
    except rospy.ROSInterruptException as e:    # An exception will be raised if the request fails
        rospy.logerr('Something went wrong: %s', e)
```

# Testing Our Code

- **Remember to give permissions to our code**
- **Now, in three separate Terminals, run the following:**
  1. **roscore**
  2. **rosrun tutorial_scripts Example_Action_Server.py**
  3. **rosrun tutorial_scripts Example_Action_Client.py**
- **In this example, our client requires a user input; make sure to give it one when requested!**

# Testing Our Program

- You should see something like this:

```
For how many seconds should I perform the action? (1<=t<=9): 5
[INFO] [1664618815.533085]: Feedback Received: seconds_elapsed: 0
[INFO] [1664618816.530901]: Feedback Received: seconds_elapsed: 1
[INFO] [1664618817.530846]: Feedback Received: seconds_elapsed: 2
[INFO] [1664618818.530541]: Feedback Received: seconds_elapsed: 3
[INFO] [1664618819.531781]: Feedback Received: seconds_elapsed: 4
[INFO] [1664618820.539802]: Result Received: success: True
```

**Client**

```
[INFO] [1664618815.529325]: Action Request Received (seconds_requested: 5) - Per
forming Action...
[INFO] [1664618820.530307]: SUCCESS - Action Complete after 5 seconds
 ---
```

**Server**

- The client node sends a goal to the server to perform the action for a given number of seconds

- The service node does this while providing feedback each second, and eventually returns success when done

# Introducing Launch Files

- Launch files allow you to execute multiple programs at once
  - Also allow you to specify launch arguments and parameters for your programs
- You can also include launch files within other launch files
  - Allows you to build up more complex launch systems from simpler ones!

# Creating a Launch File

- **Navigate to tutorial_scripts and create a folder named launch**
  - This folder will contain all our custom launch files
- **Inside that folder, create a file Example_Action_Server.launch and open it**
- **Enter the following (note - not in Example Scripts!):**

```xml
<?xml version="1.0" encoding="UTF-8"?>
<launch>

  <node name="ExampleActionServerNode" pkg="tutorial_scripts" type="Example_Action_Server.py" respawn="false" output="screen"/>

</launch>
```

# Creating a Launch File

- This launch file sets up our Example Action Server as a node
- We must specify:
  - The name for the node in the ROS system
  - The package wherein the program can be found
  - The program file (in this case the Python script)

*The last two arguments are also important so make sure to always specify them as well*

```xml
<?xml version="1.0" encoding="UTF-8"?>
<launch>

  <node name="ExampleActionServerNode" pkg="tutorial_scripts" type="Example_Action_Server.py" respawn="false" output="screen"/>

</launch>
```

# Testing Our Code (Again)

- **Now, in two separate Terminals, run the following:**

  1. **roslaunch tutorial_scripts Example_Action_Server.launch**
  2. **rosrun tutorial_scripts Example_Action_Client.py**

- Note that setting up a node using a launch file automatically starts ROSCORE in the background, therefore we don't have to start it ourselves

# Closing Thoughts – Comparing Methods

**Publisher/Subscriber:**

- Many-to-many system
- One-way communication
- Basis for all ROS systems, including Services & Actions

**ROS Services:**

- Request/response system
- Two-way communication
- Use for requesting fast processes

**ROS Actions:**

- Request/response system...
- …with feedback
- Two-way communication
- Use for requesting extended processes

# Summary

We covered:

- Overview for ROS Actions
- Defining a new ROS Action
- Brief introduction to Object-Oriented Programming
- Creating our first ROS Action Client/Server pair
- Brief introduction to launch files

**Homework: Revise ROS Actions (p.4), go over the code and make sure you can follow what's going on**

Next time, we will learn how to create autonomous behaviour for robots using State Machines!

# Thank You!

Any Questions? Contact jacques.cloete@stx.ox.ac.uk