**Exploring ROS2 nodes and topics using the MentorPi robot.**

Important notes:

* The tab key gives the ability to autocomplete commands to prevent entering the entire line.
* After every restart ensure that app control is disabled when using the terminal as detailed in step1

### **GNOME Terminator - WikipediaTerminator Commands**

|  |  |
| --- | --- |
| Ctrl + C | Stop execution in a terminak |
| Ctrl + L | Clear the terminal |
| Ctrl+S­hift+O | Split terminals Horizo­ntally. |
| Ctrl+S­hift+E | Split terminals Vertic­ally. |
| Ctrl+S­hift+T | Open new tab. |
| Ctrl+S­hift+X | Toggle terminal full screen |

1. Stop app control with the following command.

**~/.stop\_ros.sh**

1. Enter the command below.

**ros2 node list**

Notice that nothing appears since there are no nodes that are on the ROS2 network.

1. Enter: **ros2 topic list**

You should see two topics shown. These are internal to ROS2 itself and are used to manage the specific nodes and topics.

1. Enter the following:

**ros2 launch ros\_robot\_controller ros\_robot\_controller.launch.py**

This command starts a launch file that can be configured to do a variety of things related to the robots operation. In particular, this launch file starts the **ros\_robot\_controller** node as well as handles a few other configuration tasks.

Confirm that the node mentioned above is running by entering: **ros2 node list**

Check which topics the node establishes with the command: **ros2 topic list**

1. Let’s look at HOW messages are sent on specific topics. We will chose the /ros\_robot\_controller/set\_rgb topic and look at what **interface** it uses.

Enter: **ros2 topic info /ros\_robot\_controller/set\_rgb**

You should see that this topic has one subscriber and no publishers. That means that one other node is listening to messages that this topic broadcasts.

You should see under ‘type’ that there is an interface for this topic that is called ‘RGBStates’

Enter: **ros2 interface show ros\_robot\_controller\_msgs/msg/RGBStates**

You will see that there are four data types that this interface uses:

int32 index

uint8 red

uint8 green

uint8 blue

This represents which led to trigger and the value it should take

You are now ready to send commands (publish) commands on this topic using the interface queried.

NOTE: Some topics such as set\_motor require other nodes to be launched. SO while we can do the same for this (and any other) topic, we might not be able to do anything useful yet.

1. Let’s publish to the topic to remontely trigger an LED on the robot enter the following (Don’t press enter until everything is typed it as shown):

**ros2 topic pub /ros\_robot\_controller/set\_rgb ros\_robot\_controller\_msgs/msg/RGBStates "{states: [**

**{index: 1, red: 255, green: 0, blue: 0},**

**{index: 2, red: 255, green: 0, blue: 0}**

**]}"**

Notice the text on your screen that says publishing #<n> and that the two LEDs on your robot have turned red.  
This confirms that your message is being received by a **node that subscribes to the /ros\_robot\_controller/set\_rgb topic**.  
That node runs code which processes the message and **physically sets the LED colors** on the robot.

1. Try it – use what you learned to learn about the /ros\_robot\_controller/battery topic.

What is the msg type (interface) used by the battery topic: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Notice that /ros\_robot\_controller/battery is a **publisher** topic — this means a node is **sending data** on this topic, and any other node can subscribe to receive the battery readings. This topic **does not receive** data; it only **publishes** battery status updates.

9) We can view the data that is being published by using: **ros2 topic echo /ros\_robot\_controller/battery**

We can observe something like this: data: 7651

This represents battery voltage in mV, so 7651mV = 7.65V

**High-Level Movement Data**

Now let’s start digging into the system that allows the robot to move efficiently by calculating its position. There are two types of data that need to be considered, IMU and odometry.

IMU calculates the acceleration and angular velocity of the robot in each of its three axes.

Odometry uses encoders on the wheels to calculate the motion of the wheels.

1. We can start the main controller as in step 4:

**ros2 launch ros\_robot\_controller ros\_robot\_controller.launch.py**

1. We then need to start the IMU controller:

**ros2 launch peripherals imu\_filter.launch.py**

1. If we examine the new topics that the IMU introduced: **ros2 topic list**

…. We can see that there is a new /imu and /imu\_corrected topic.

By typing **ros2 topic info /imu**, we can see that one node is publishing to this topic — which means that IMU data is being sent and is available for other nodes to receive.

1. Just like with the battery topic, we can view the data being published on the /imu topic using:

**ros2 topic echo /imu**

There is a lot of data that moves fast. It should look something like the image here:

You might notice that if you move the robot some of the numbers will begin to change. This shows a change in the **angular velocity** and **linear acceleration**

1. Now let’s view the odometry data. Start your controller (or ensure it is running):

**ros2 launch controller controller.launch.py**

1. Look for the **/odom** topic in your topic list

**ros2 topic list**

We can also see HOW MANY topic are running (we should see 33):

**ros2 topic list | wc -l**

A computer screen with white text

AI-generated content may be incorrect.

1. Let’s view data that shows the position and orientation of the robot in the three axes.

**ros2 topic echo /odom**

While the topic data is displayed move the robot around. While moving the robot press **ctrl+c**. Then scroll up to observe the data. This makes it a little easier to see changes then to keep up with the data being echoed.

Another useful source of data that shows both linear acceleration and angular velocity is: **/imu\_corrected**

**High-Level Movement Control**

Let’s now drive the robot by publishing data on linear and angular velocity.

The **linear velocity** (relative to the robot) is the ***x-axis*** which represents forward and backward movement. This can range from about **-0.6 to 0.6 (m/sec)**

The **angular velocity** (relative to the robot) is ***z-axis*** which represents the left and right turn. This can range from **-2 (full right) to 2 (full left)**

1. The /cmd\_vel command is what enables high level movement control (common in many ROS applications). Let’s see what type of message the cmd\_vel topic uses:

**ros2 topic info /cmd\_vel**

We see - **Type:** **geometry\_msgs/msg/Twist**

18) Let’s inspect how these messages are structured:

**ros2 interface show geometry\_msgs/msg/Twist**

This shows that the message contains:

* A linear field with 3 float values (x, y, z)
* An angular field with 3 float values (x, y, z)  
  These are used to represent linear and angular velocity in 3D space.

19) Let’s send move commands by publishing to the velocity control topic using the message type we observed:

**ros2 topic pub /controller/cmd\_vel geometry\_msgs/Twist "linear:**

**x: 0.2**

**y: 0.0**

**z: 0.0**

**angular:**

**x: 0.0**

**y: 0.0**

**z: 0.0"**

This command tells the robot to **drive forward at 0.2 m/s with no rotation**.

⚠️ Make sure the motion controller node is running (ros2 launch controller controller.launch.py), or the robot will not respond.

⚠️ Make sure the robot is on a flat surface and has room to move

⚠️ It’s a good idea to have a second window open and ready to send a follow up stop command whenever a move command of this sort is published.

**ros2 topic pub /controller/cmd\_vel geometry\_msgs/Twist "linear:**

**x: 0.0**

**y: 0.0**

**z: 0.0**

**angular:**

**x: 0.0**

**y: 0.0**

**z: 0.0"**

**LiDAR (Light Detection and Ranging)**

A LiDAR on a robot or autonomous vehicle collects thousands of distance readings per second. As it rotates, it emits laser pulses and measures the time it takes for each pulse to bounce back. By combining this timing with the angle of each pulse, the LiDAR builds a detailed 2D (or sometimes 3D) map of its surroundings. This data provides accurate information about the shape and distance of nearby objects, helping the robot detect obstacles, navigate, and understand its environment. As it continuously scans, the LiDAR updates this map in real time, enabling effective navigation and environmental awareness.

In more advanced LiDARs, the system can generate full 3D maps by using multiple laser beams or by tilting the sensor, and some can even measure the velocity of moving objects using Doppler shift, enabling detailed perception for applications like autonomous driving and high-precision mapping.

20) Double check app control is disabled: **~/.stop\_ros.sh**

21) Launch the LiDAR control stack:

**ros2 launch app lidar\_node.launch.py debug:=true**

By viewing the active topics **ros2 topic list**

…we can see that:

1) the topics from the launch controller all appear as we used previously

2) A new topic **/scan\_raw has** appeared

23) Tell the robot to begin processing lidar data by entering:

**ros2 service call /lidar\_app/enter std\_srvs/srv/Trigger {}**

You can confirm that data is being sent from the LiDAR by entering: **ros2 topic echo /scan\_raw**

24) The LiDAR has a few different working modes (which is often the case in many other robotic systems built on ROS).

Enter the following:

**ros2 service call /lidar\_app/set\_running interfaces/srv/SetInt64 "{data: 2}"**

This put the robot into ‘Following’ mode. If you (or any object) is in the field of view of the robot and moves, the robot will attempt to follow it while maintain its distance.

We can stop this behavior and put the robot back into idle with the command:

**ros2 service call /lidar\_app/set\_running interfaces/srv/SetInt64 "{data: 0}"**

25) Now, let’s put the robot into **Obstacle Avoidance** mode. In this mode, the robot will navigate its surroundings and actively avoid obstacles — as long as those obstacles are at or above the height of the LiDAR sensor.

Enter:

**ros2 service call /lidar\_app/set\_running interfaces/srv/SetInt64 "{data: 1}"**

**⚠️ Safety Note**

Avoid testing near edges or stairs — the robot does **not** currently have any mechanism running to detect or avoid drop-offs.

Keep in mind, putting in ‘0’ for data will again put the robot and LiDAR in standby.

The chart below summarizes the modes:

|  |  |  |
| --- | --- | --- |
| **data value** | **Mode** | **Description** |
| **0** | **Standby** | **Idle, not doing anything** |
| **1** | **Obstacle Avoidance** | **Moves forward while avoiding obstacles** |
| **2** | **Following** | **Follows a moving object in front of the robot** |
| **3** | **Guarding** | **Turns to keep front pointed at object in view (not available on Ackermann chassis)** |

**Depth Camera**

The MentorPi robot is equipped with a **binocular 3D depth camera** that allows it to **see and understand its surroundings in three dimensions**. Unlike a regular camera that only captures color, the depth camera also measures **how far away each part of the scene is**, creating a “depth map” of the environment.

26) Run the following two commands to stop the app control and activate the depth camera topics:

**~/.stop\_ros.sh**

**ros2 launch peripherals depth\_camera.launch.py**

27) ROS2 has a built in tool that allows developers to visualize and debug data from a system. We will use the tool to view the output from the camera. In the command line enter the following:

**rqt**

This should bring up the rqt tool

In the tool go to: **Plugins > Visualization > Image View**

In the drop down box at the top make sure **/ascamera/camera\_publisher/rgb0/image** is selected

28) We also have the ability to view our video feed from a browser. To do this we first have to re-enable app service in the terminal (NOT THE DOCKER CONTAINER!)

 Enter: **sudo systemctl restart start\_node.service**

A screenshot of a computer

AI-generated content may be incorrect.29) Now we can bring up a broswer and enter:

[**http://192.168.149.1:8080/**](http://192.168.149.1:8080/)

Alternatively, as long as we are running in AP mode we can enter:

[**http://localhost:8080/**](http://localhost:8080/)

Either way are broweser should opn something like the image here:

Clicking on ‘image’ below /ascamera/camera\_publisher/rgb0/ will bring up the video feed

**AI and Machine Learning**

The MentorPi comes with built in AI models that allow it to do a number of things such as pose detection, posture control and autonomous driving.

**Fingertip Trajectory Recognition**

30) Start the depth camera:

**ros2 launch peripherals depth\_camera.launch.py**

31) Change directories to the hand recognition program:

**cd ros2\_ws/src/example/example/mediapipe\_example**

32) Start the hand recognition program:

**python3 hand\_gesture.py**

A hand drawing a heart on a graph

AI-generated content may be incorrect.A hand with lines and dots on a screen

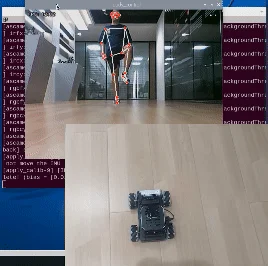
AI-generated content may be incorrect.If the robot detects the “**1**” gesture, the trajectory of your fingertip motion will begin to be recorded on the live camera feed. If it detects the “**5**” gesture, the recorded fingertip trajectory will be cleared.

**Posture Control**

Stop all previous nodes **~/.stop\_ros.sh**

33) Start the posture control program:

**ros2 launch example body\_control.launch.py**

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When the program starts make sure the body is fully in the robots view.

From the perspective of the robot, when you raises you left arm, the robot will turn left; when your right arm is raised, the robot will turn right; when your left leg is raised, the robot will move forward; and when your right leg is raised, the robot will move backward.

**Pose Detection**

34) Start the pose detection program:

**ros2 launch example fall\_down\_detect.launch.py**

A person standing in a room with a robot

AI-generated content may be incorrect.Ensure the body is within the view of the camera. Quickly get into a pose like your are trying to sit down on a chair.

The robot will register this pose as **‘falling’.** It will beep and move back and fourth as though it is ‘panicking’ or calling for help.