Building your own open source robot

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An Introduction to ROS

Building your own Open Source robot

Part 1: ROS Basics

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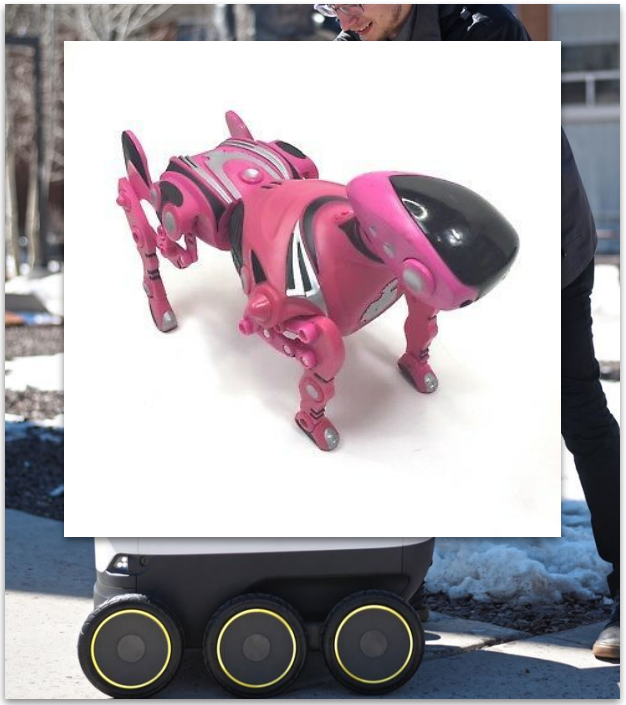
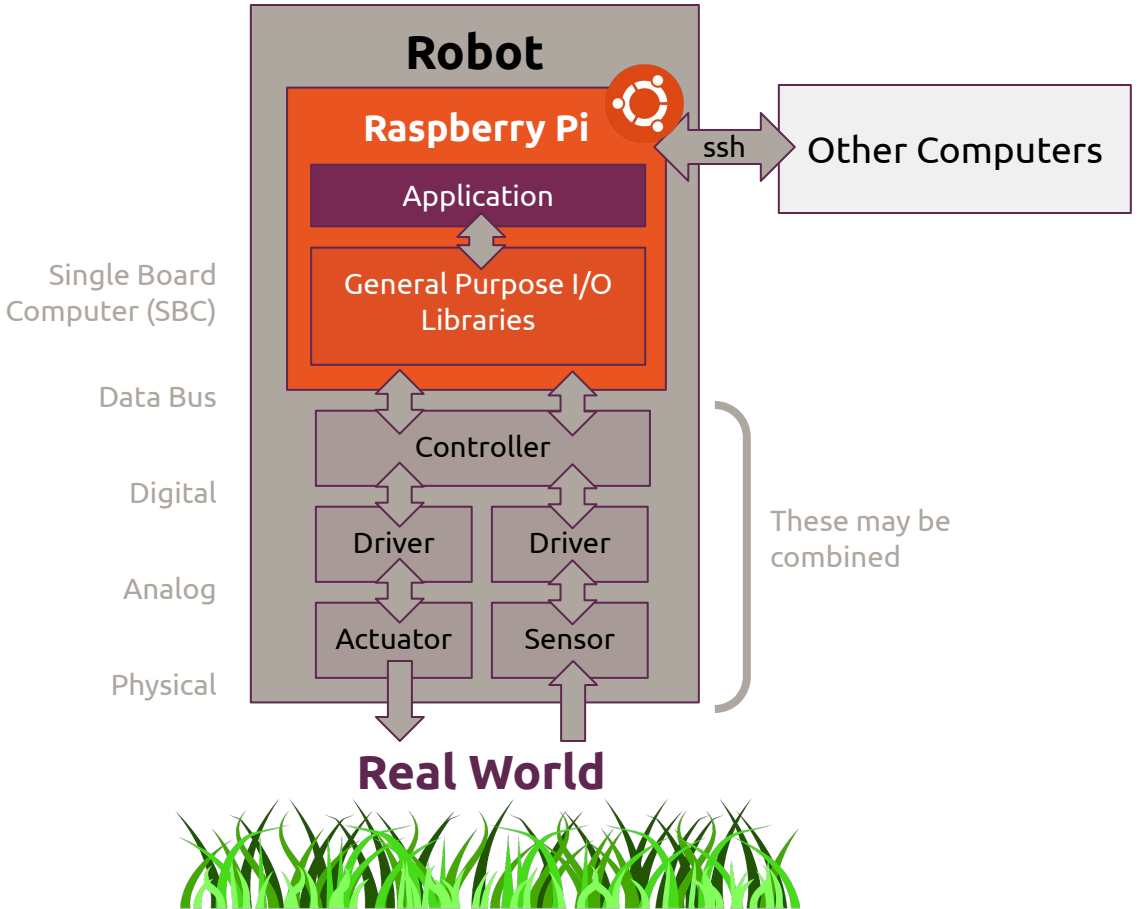
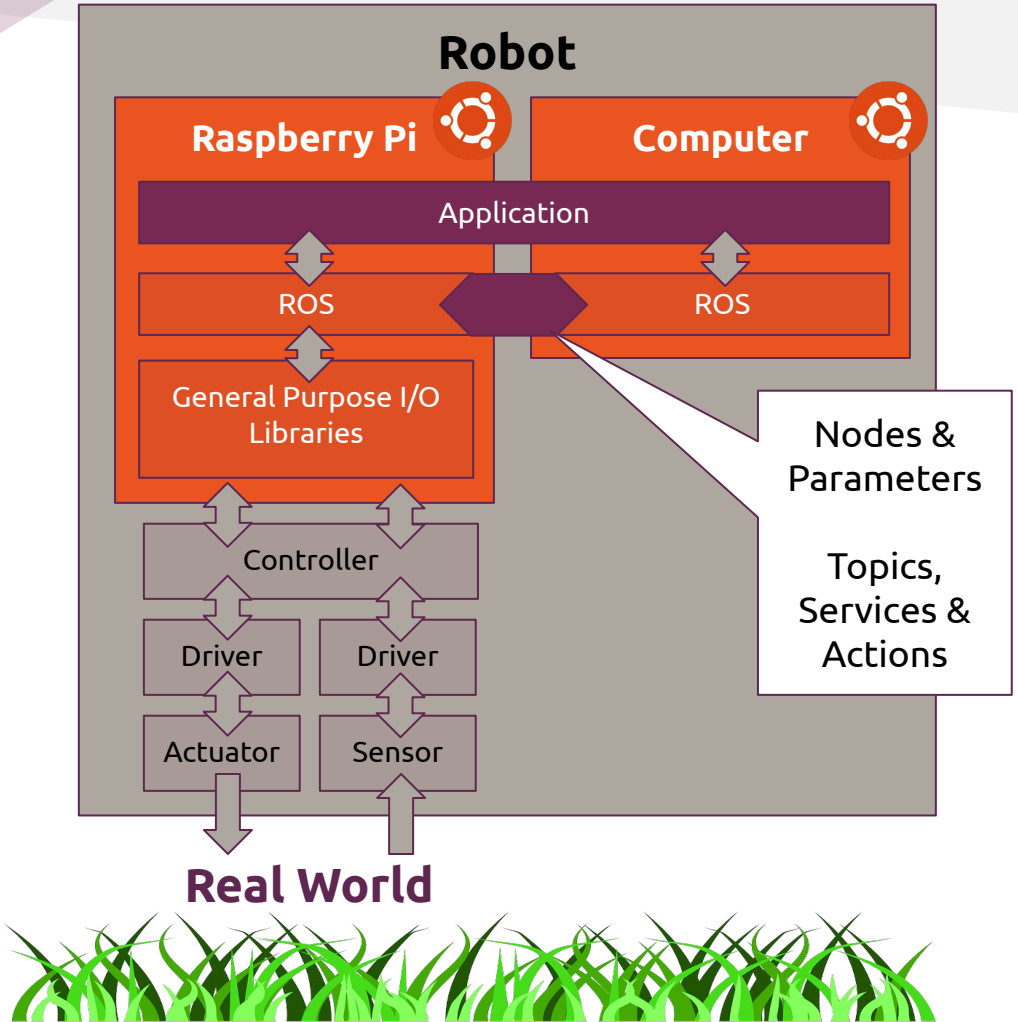
The current state of robotics



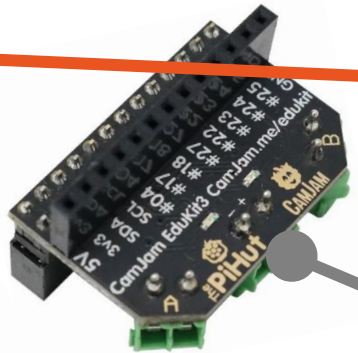
What is a [simple] robot?

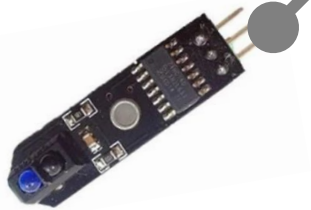


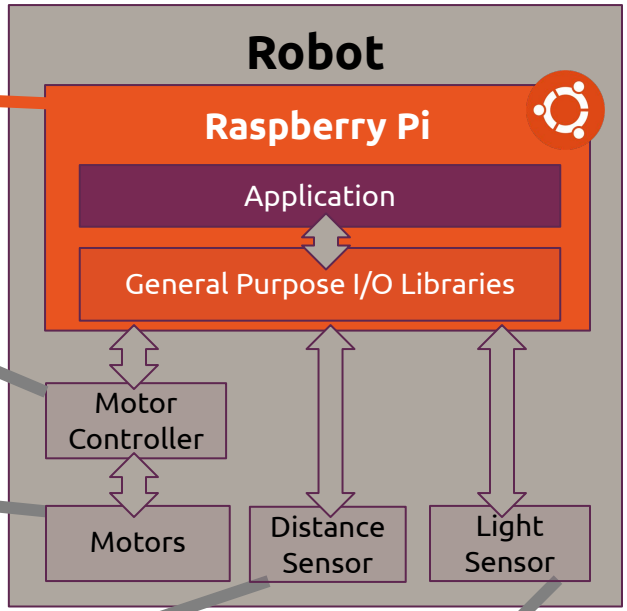
A ROS robot


Robot
Raspberry Pi
Computer
Application
ROS
ROS
General Purpose I/O Libraries
Nodes & Parameters
Topics, Services & Actions
Controller
Driver
Driver
Actuator
Sensor
Real World

Wheelie hardware: Motors and Sensors





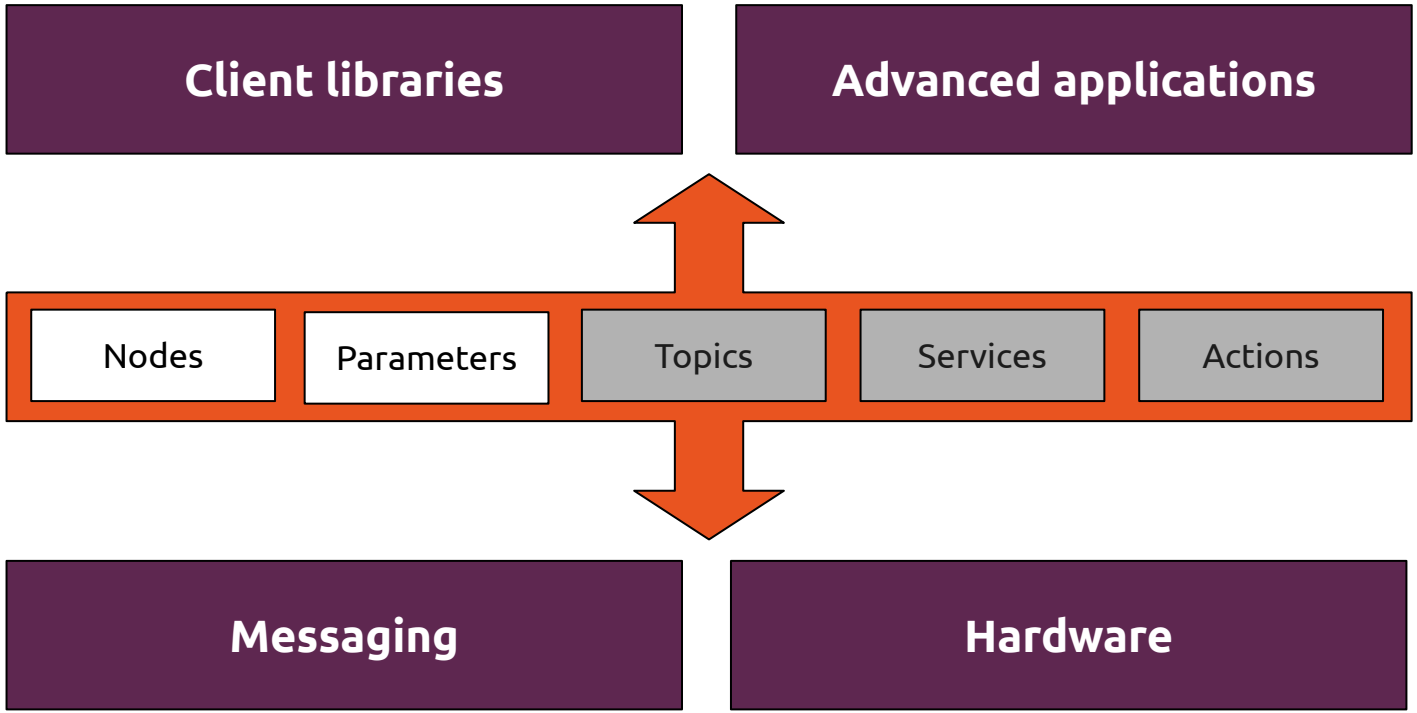


ROS architecture

ROS Structure

Nodes	A low level computational process
Parameters	Node runtime shared multi-variate dictionary
Topics	A named bus (pub/sub) over which nodes broadcast and receive messages (one-way)
Services	Request/response synchronous interaction with a node
Actions	Asynchronous goal request of a server, with periodic updates back to the client

ROS 2 middleware



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Part 2: Install the OS and put the parts together

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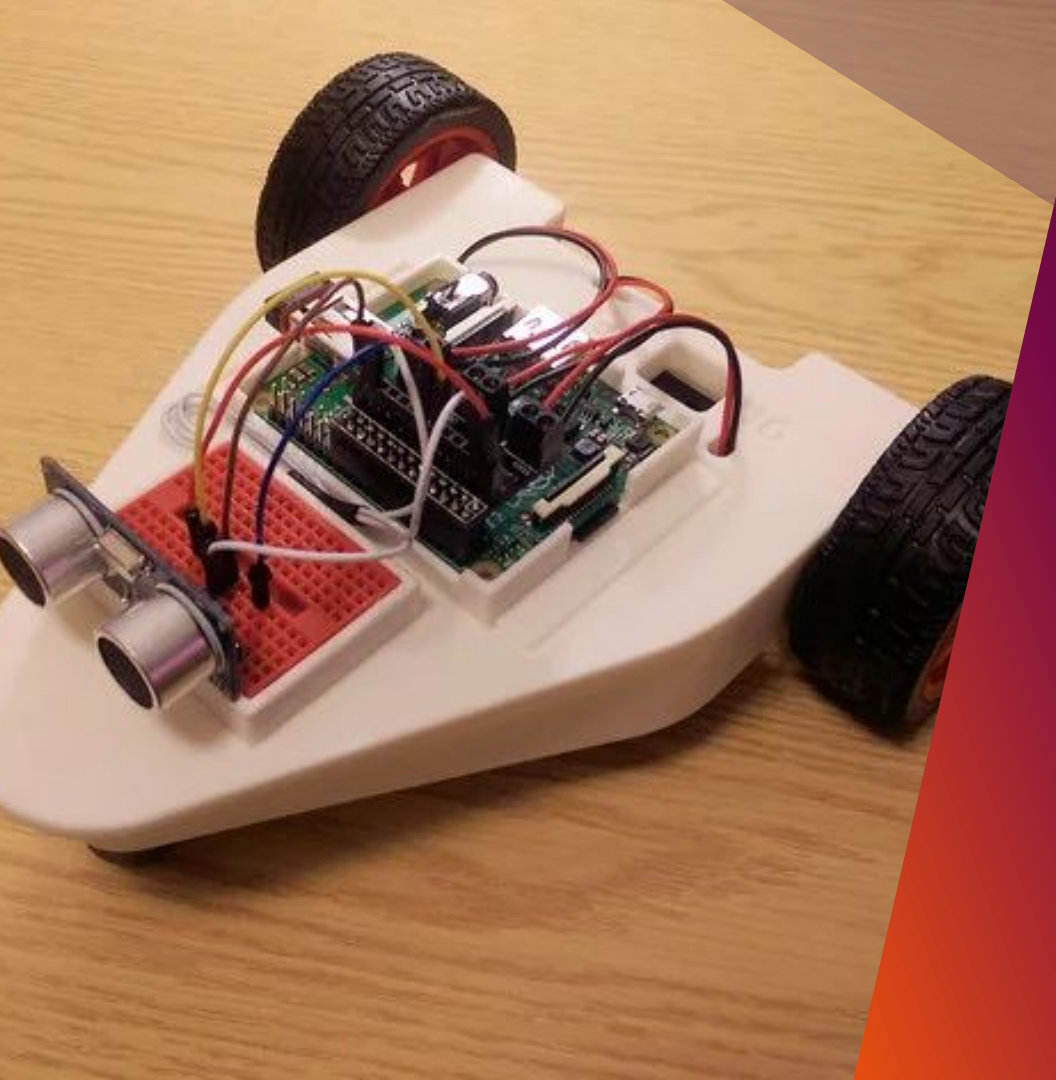
RasPi Build Steps

Install Ubuntu

Install ROS

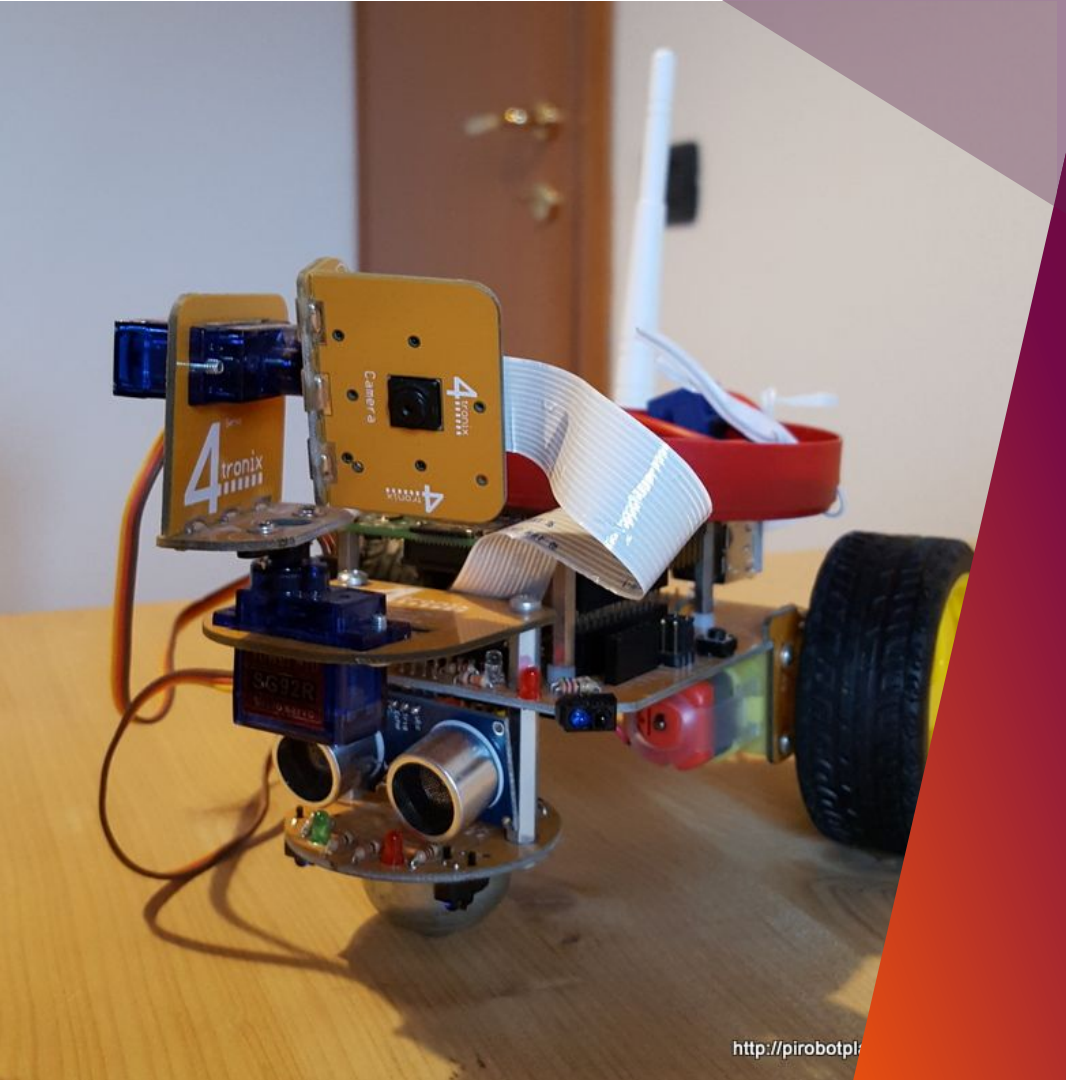
Clone the code repository

The Build



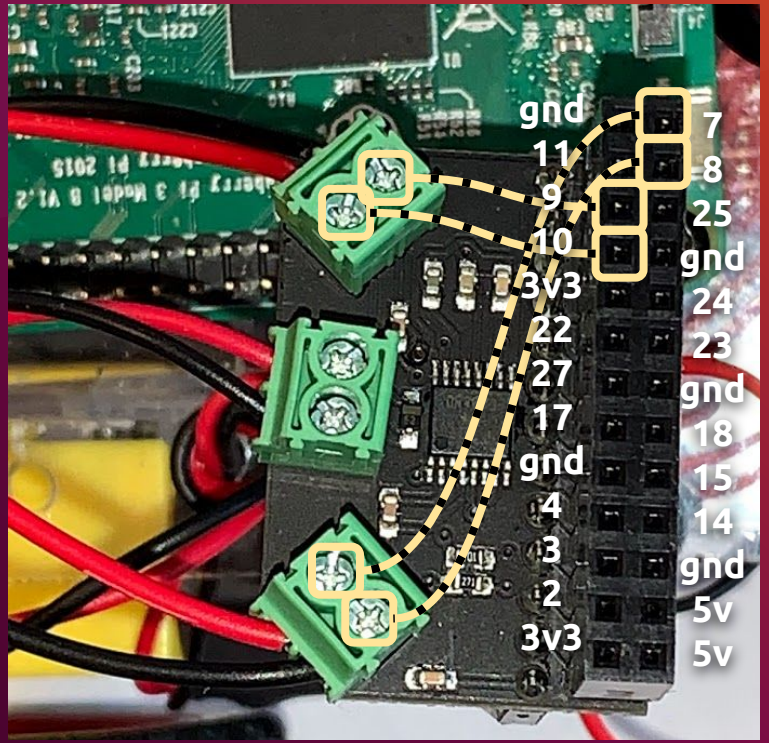
https://www.thingiverse.com/thing:1113796

https://github.com/fustinoni-net/PiRobotPlatform



https://github.com/fustinoni-net/PiRobotPlatform

Pin 7	Left Fwd
Pin 8	Left Back
Pin 9	Right Back
Pin 10	Right Fwd



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Part 3: Controlling hardware with ROS

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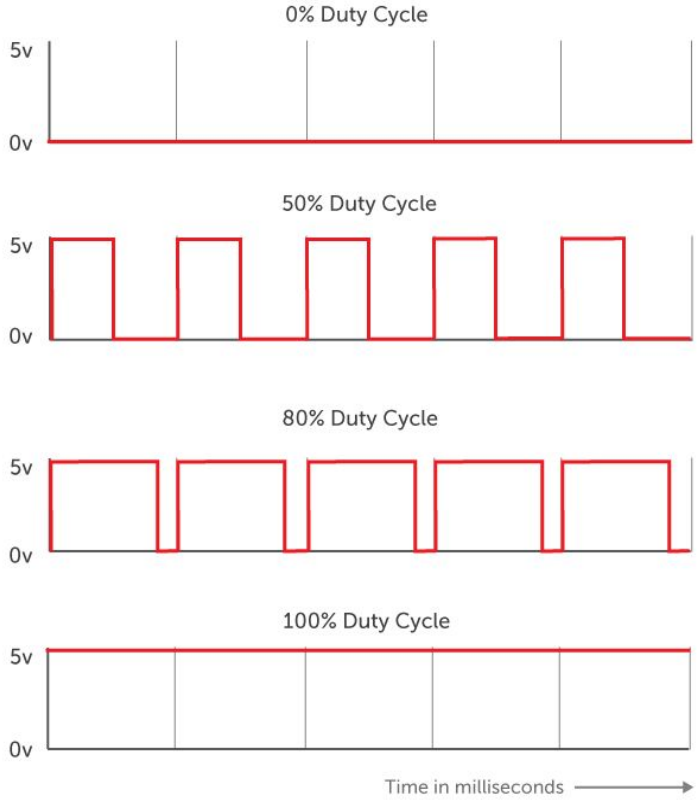
Move forward for one second

```
#! /usr/bin/python3
import RPi.GPIO as GPIO
import time

#  GPIO initialization
GPIO.setmode (GPIO.BCM)
GPIO.setwarnings (False)

#  set GPIO pin mode
GPIO.setup (7, GPIO.OUT)
GPIO.setup (8, GPIO.OUT)
GPIO.setup (9, GPIO.OUT)
GPIO.setup (10, GPIO.OUT)

#  turn motors off
GPIO.output(7,0)
GPIO.output(8,0)
GPIO.output(9,0)
GPIO.output(10,0)

#  turn right motor forward
GPIO.output(7,0)
GPIO.output(8,1)

#  turn left motor forward
GPIO.output(9,0)
GPIO.output(10,1)

time.sleep(1)

#  Reset GPIO and turn off motors
GPIO.cleanup()
```

Controlling motor speed: frequency and duty cycle




```
GPIO.setup (pinRFwd,  GPIO.OUT)
Frequency=20

#  set up PWM on pinRFwd at frequency 20
pwmRFwd  = GPIO.PWM (pinRFwd,  Frequency)

#  initialize pwm with a duty cycle of 0
pwmRFwd.start (0)

#  Change duty cycle to 0 after start
pwmRFwd.ChangeDutyCycle(0)

#  Change duty cycle to 50%
pwmRFwd.ChangeDutyCycle(50)

#  Change duty cycle to 80%
pwmRFwd.ChangeDutyCycle(80)

#  Change duty cycle to 100%
pwmRFwd.ChangeDutyCycle(100)
```

Image source: https://www.pubnub.com/blog/building-raspberry-pi-smart-house-part-2. For more about RPi.GPIO, see https://sourceforge.net/p/raspberry-gpio-python/wiki/Examples/.

Adding ROS to the Motor class

```
#! /usr/bin/python3

import rclpy
from rclpy.node import Node
from std_msgs.msg import String
import RPi.GPIO as GPIO
import time

GPIO.setmode (GPIO.BCM)
GPIO.setwarnings (False)

[include the Motor and Wheelie classes]

class MinimalSubscriber(Node):
    def __init__(self):
        super().__init__('minimal_subscriber')
        self.subscription = self.create_subscription(
            String,
            'move',
            self.listener_callback,
            10)
        self.subscription  arning
        self.wheelie = Wheelie()
```

```
def listener_callback(self, msg):
    command = msg.data
    if command == 'forward':
        print('Moving forward')
        self.wheelie.goForward()
    elif command == 'backward':
        print('Moving backward')
        self.wheelie.goBackward()
    elif command == 'left':
        print('Turning left')
        self.wheelie.goBackward()
    elif command == 'right':
        print('Turning right')
        self.wheelie.goRight()
    elif command == 'stop':
        print('Stopping')
        self.wheelie.stop()
    else:
        print('Unknown command, stopping instead')
        self.wheelie.stop()
```

ros_helloworld.py

Adding ROS to the Motor class (2)

```
def main(args=None):
    #  initialize the wheelie node
    rclpy.init(args=args)
    minimal_subscriber = MinimalSubscriber()

    #  wait for incoming commands
    rclpy.spin(minimal_subscriber)

    #  Interrupt detected, shut down
    minimal_subscriber.wheelie.stop()
    GPIO.cleanup()
    minimal_subscriber.destroy_node()
    rclpy.shutdown()


if __name__ == '__main__':
    main()
```

ros_helloworld.py

Drive the Wheelie

On the Wheelie:

```
source /opt/ros/eloquent/setup.bash
./ros_helloworld.py
```

On your Laptop:

```
source /opt/ros/eloquent/setup.bash
ros2 topic pub '/move' \
     'std_msgs/String' \
     '{data: forward}'
```

...or run rqt to publish messages to the /move topic

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Part 4: Adding a joystick

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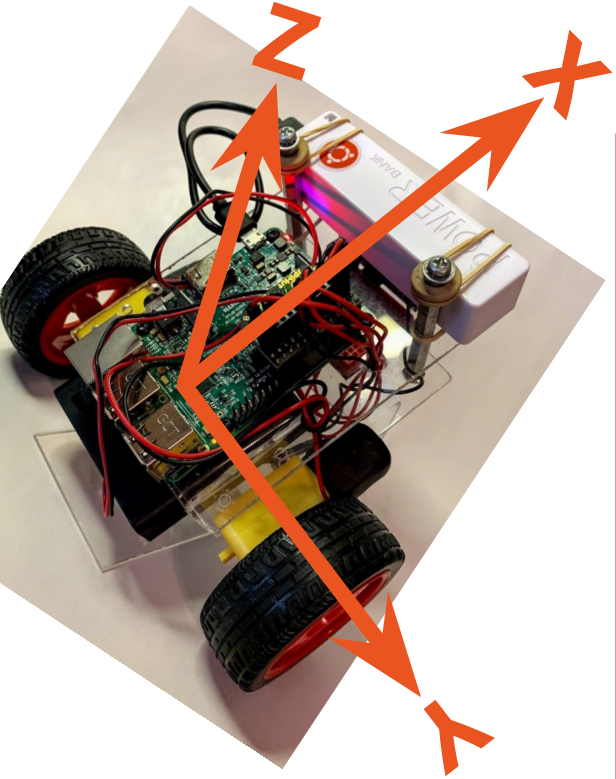
Keyboard Control:

ros2 run teleop_twist_keyboard teleop_twist_keyboard



geometry_msgs/Twist

linear: Vector3

- x: forward meters/second
- y: left
- z: up

angular: Vector3

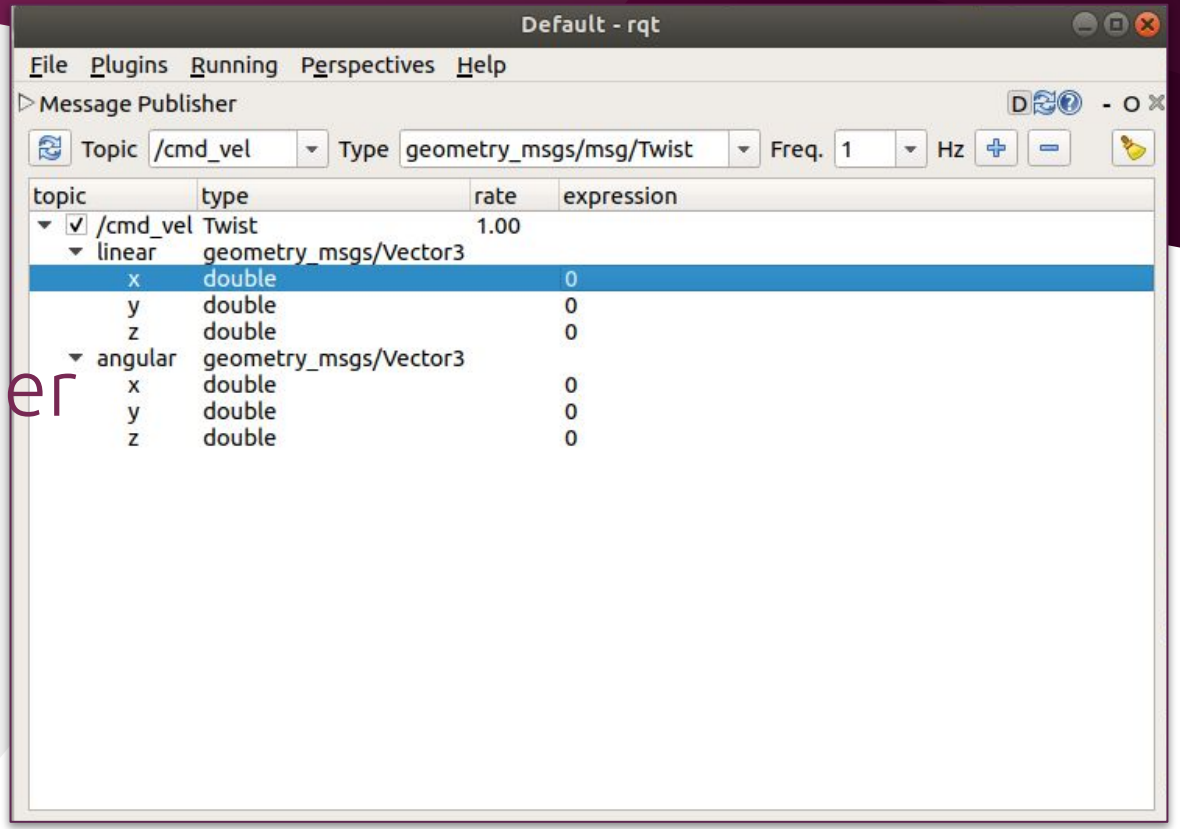
- x: radians/second
- y: radians/second
- z: rotation radians/second

Make it easy

ROS tools that work with Twist

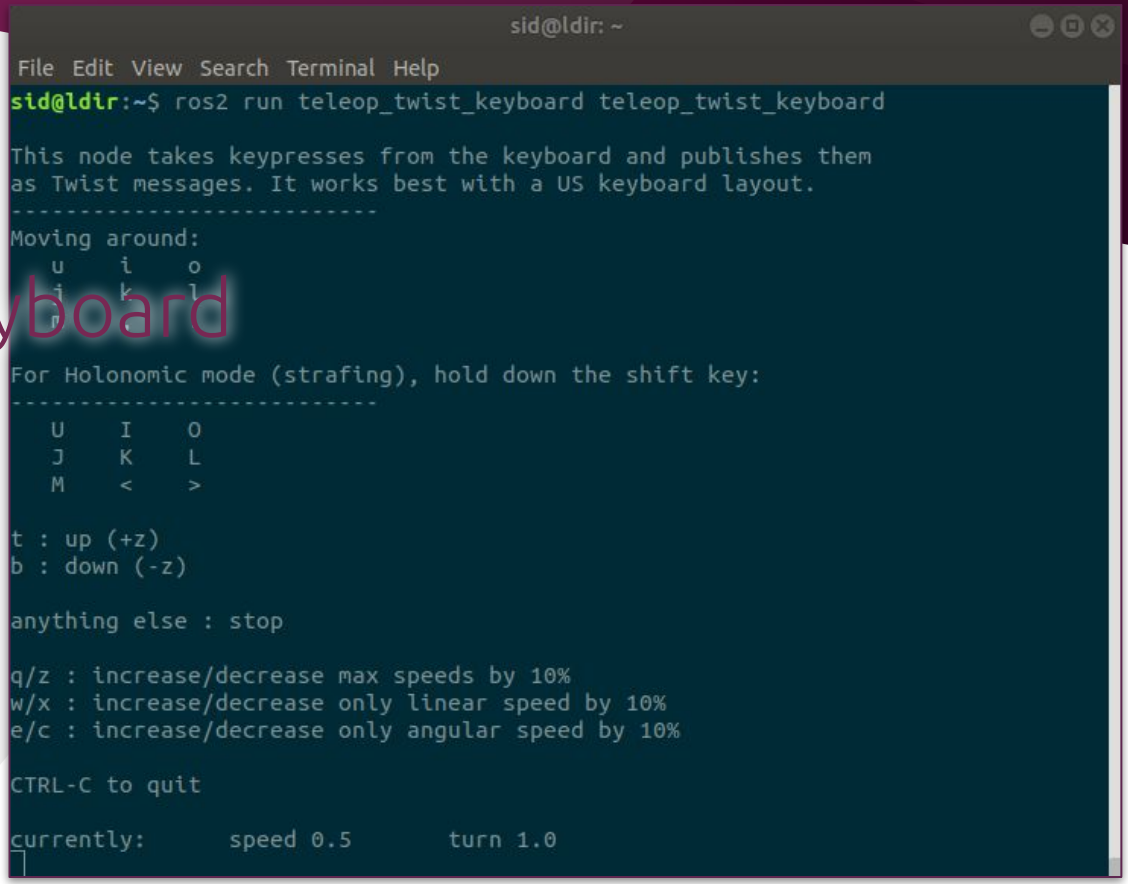
Moving the wheelie

rqt topic, Message Publisher plugin



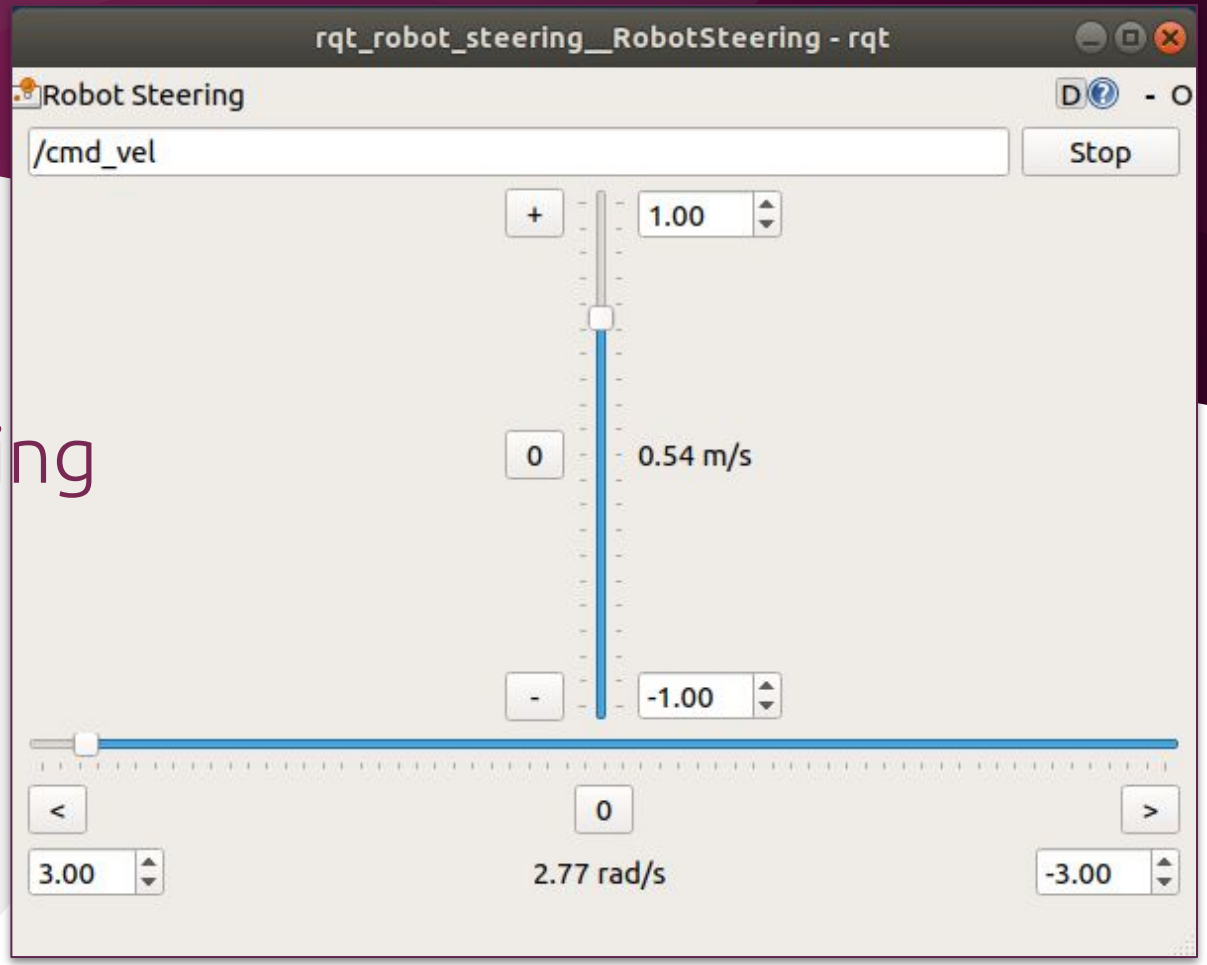
Moving the wheelie

teleop_twist_keyboard



Moving the wheelie

rqt_robot_steering



Joystick Control:

ros2 run joy joy_node

ros2 topic echo /joy

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Part 5: Adding a sensor

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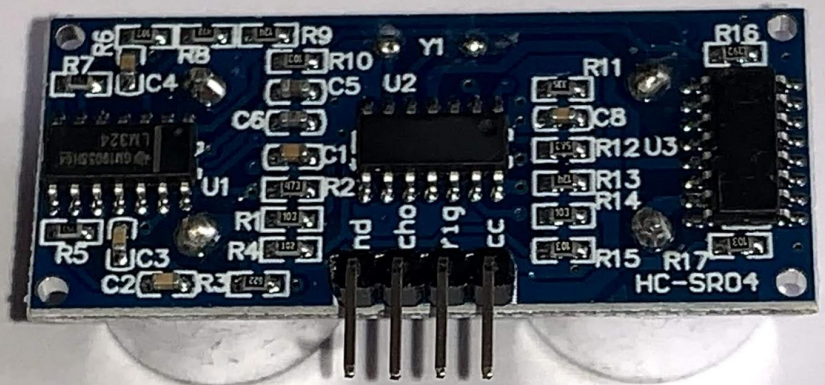
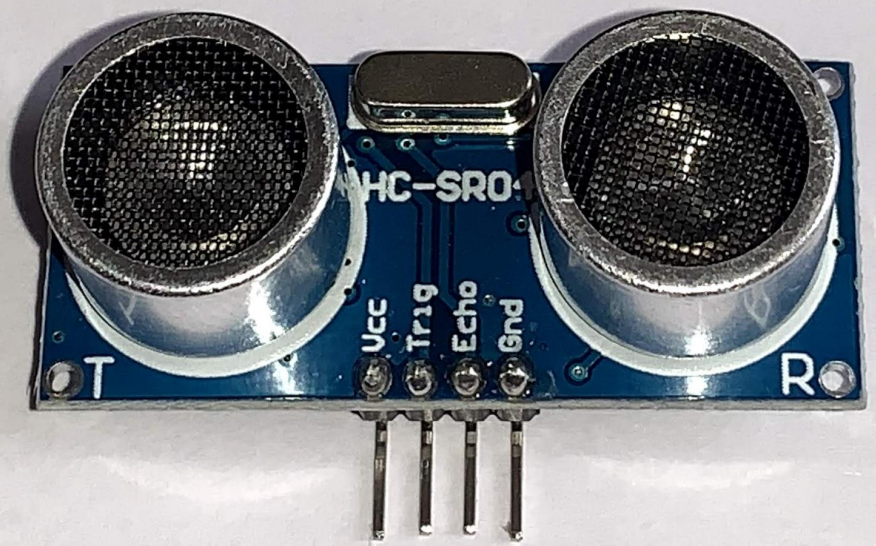

R9
R10
Y1
R16
R7
R8
C4
C5
U2
R11
C6
C8
C1
R12
U3
U1
R2
R13
R14
R1
R5
C3
R4
R15
R17
C2
R3
HC-SR04


HC-SR04
Vcc
Trig
Echo
Gnd
T
R

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