GAZEBO SIMULATION - DINGO

Dingo Quadruped Gazebo Simulation Setup & Control Guide

What is Gazebo?

Gazebo is a powerful 3D simulator used to test and visualize robots in a virtual environment. It accurately simulates real-world physics, sensors, and robot movements, making it ideal for developing and debugging robotics projects before using actual hardware.

Repository Link:https://github.com/Yerbert/DingoQuadruped/tree/master

System Requirements

- **Ubuntu**: 20.04 LTS
- **ROS**: Noetic
- **Gazebo**: Classic (version 11)
- **Python**: 3.8 or higher

1. Install Required Packages

Open a terminal and install the necessary dependencies:

bash:

```
sudo apt update
sudo apt install ros-noetic-effort-controllers
ros-noetic-ros-controllers ros-noetic-joint-state-controller
ros-noetic-ros-control ros-noetic-controller-manager
ros-noetic-teleop-twist-keyboard
```

2. Clone the Repository

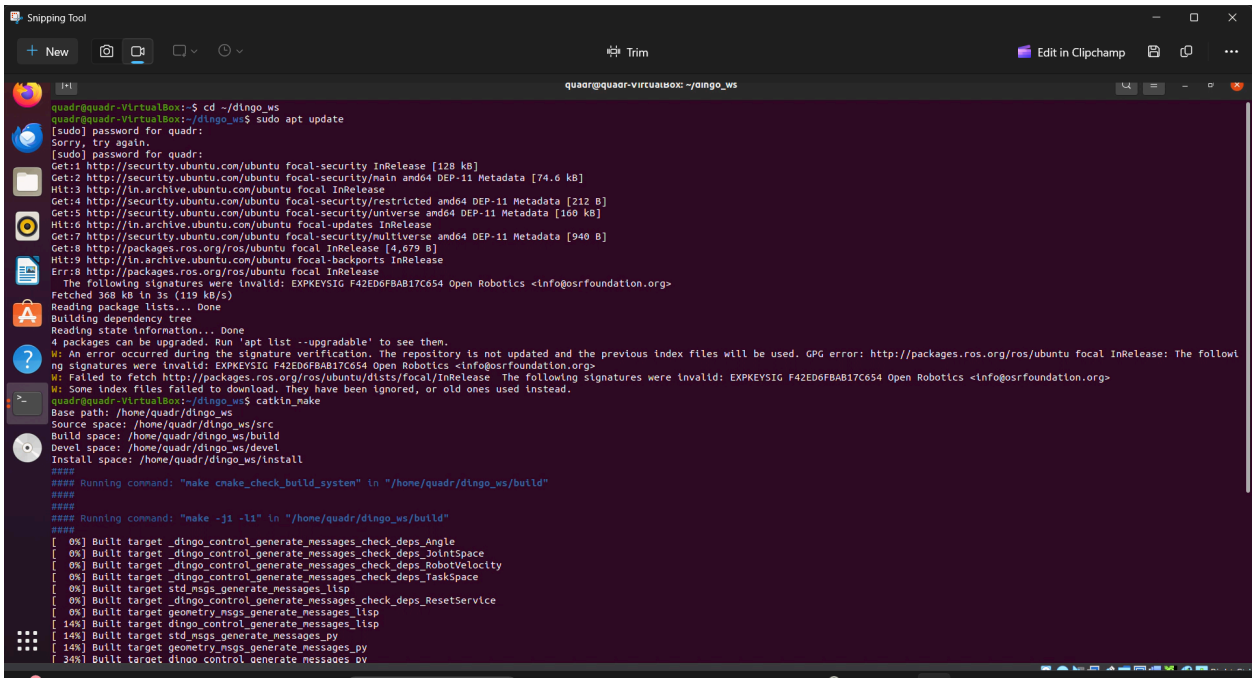
bash

```
cd ~
git clone
https://github.com/Yerbert/DingoQuadruped/tree/master/dingo_ws/s
rc.git
cd dingo_ws
```

3. Build the Workspace

bash

```
cd ~/dingo_ws
rosdep install --from-paths src --ignore-src -r -y
catkin_make
source devel/setup.bash
```



4. Launch the Robot in Gazebo

In Terminal 1, launch the Gazebo simulation:

bash

```
roslaunch dingo_gazebo simulation.launch
```

This opens the Gazebo world and spawns the quadruped robot.

gazebo video.mp4

5. Start the State Publisher

In Terminal 2, run:

bash

```
source ~/DingoQuadrupeD/dingo_ws/devel/setup.bash
roslaunch dingo_description dingo_state_publisher.launch
```

This publishes joint state and TF data for visualization and coordination.

6. Code for dingo_driver.py:

Open a new terminal.

bash:

```
cd ~dingo_ws
catkin_make
source devel/setup.bash
cd dingo_ws/src/dingo/scripts
code .
```

- This opens a folder called scripts in VS code where the following files are present.
    - dingo_driver.py
    - cmd_vel_driver.py
    - keyboard_node_input.py

- Open dingo_driver.py and paste the following:

Code:

```
import numpy as np            # 🟦 For numerical operations like arrays and matrices 🟦
import time                   # 🟦 Used for delays or time-based operations 🟦
import rospy                  # 🟦 Main ROS Python client library 🟦
import sys                    # 🟦 For accessing command-line arguments 🟦
from std_msgs.msg import Float64 # 🟦 Message type to publish float values (like joint angles) 🟦
import signal                 # 🟦 Used to handle keyboard interrupts like Ctrl+C 🟦
import socket                 # 🟦 (Optional) for network communication (not used here) 🟦
import platform               # 🟦 (Optional) to check OS (not used here) 🟦
from dingo_peripheral_interfacing.msg import ElectricalMeasurements # 🟦 Custom message for power monitoring 🟦

# 🟦 Fetch command-line arguments: is_sim, is_physical, and use_imu 🟦
args = rospy.myargv(argv=sys.argv)
if len(args) != 4:
    is_sim = 0                # 🟦 Default: not simulation 🟦
    is_physical = 1           # 🟦 Default: physical robot is used 🟦
```

```
    use_imu = 1              # 🟦 Default: use IMU sensor 🟦
else:
    is_sim = int(args[1])      # 🟦 Get is_sim flag from arguments 🟦
    is_physical = int(args[2])  # 🟦 Get is_physical flag from arguments 🟦
    use_imu = int(args[3])     # 🟦 Get use_imu flag from arguments 🟦

# 🟦 Import robot control modules 🟦
from dingo_control.Controller import Controller
from dingo_input_interfacing.InputInterface import InputInterface
from dingo_control.State import State, BehaviorState
from dingo_control.Kinematics import four_legs_inverse_kinematics
from dingo_control.Config import Configuration
from dingo_control.msg import TaskSpace, JointSpace, Angle
from std_msgs.msg import Bool

# 🟦 Import hardware-specific modules only if using physical robot 🟦
if is_physical:
    from dingo_servo_interfacing.HardwareInterface import HardwareInterface
    from dingo_peripheral_interfacing.IMU import IMU
    from dingo_control.Config import Leg_linkage

class DingoDriver:
    def __init__(self, is_sim, is_physical, use_imu): # 🟦 Constructor 🟦
        self.message_rate = 50                    # 🟦 50 Hz control loop 🟦
        self.rate = rospy.Rate(self.message_rate)    # 🟦 ROS loop rate object 🟦

        self.is_sim = is_sim                    # 🟦 Store simulation mode 🟦
        self.is_physical = is_physical            # 🟦 Store physical robot mode 🟦
        self.use_imu = use_imu                    # 🟦 Store IMU usage flag 🟦

        # 🟦 ROS Subscribers 🟦
```

```
        self.joint_command_sub = rospy.Subscriber("/joint_space_cmd", JointSpace,
self.run_joint_space_command)
        self.task_command_sub = rospy.Subscriber("/task_space_cmd", TaskSpace,
self.run_task_space_command)
        self.estop_status_sub = rospy.Subscriber("/emergency_stop_status", Bool,
self.update_emergency_stop_status)
        self.external_commands_enabled = not self.is_physical # 🟦 Enable external
commands in sim 🟦

        rospy.loginfo(f"DingoDriver: External commands enabled:
{self.external_commands_enabled} (derived from is_physical={self.is_physical})")

        # 🟦 Simulation joint controllers 🟦
        if self.is_sim:
            self.sim_command_topics = [  # 🟦 Topics for 12 simulated joint controllers 🟦
                "/dingo_controller/FR_theta1/command",
                "/dingo_controller/FR_theta2/command",
                "/dingo_controller/FR_theta3/command",
                "/dingo_controller/FL_theta1/command",
                "/dingo_controller/FL_theta2/command",
                "/dingo_controller/FL_theta3/command",
                "/dingo_controller/RR_theta1/command",
                "/dingo_controller/RR_theta2/command",
                "/dingo_controller/RR_theta3/command",
                "/dingo_controller/RL_theta1/command",
                "/dingo_controller/RL_theta2/command",
                "/dingo_controller/RL_theta3/command"
            ]

            self.sim_publisher_array = []  # 🟦 Publishers to send commands to Gazebo 🟦
            for topic in self.sim_command_topics:
                self.sim_publisher_array.append(rospy.Publisher(topic, Float64, queue_size=0))
```

```
        self.config = Configuration()    # 🟦 Load config values 🟦

        if is_physical:
            self.linkage = Leg_linkage(self.config)        # 🟦 Linkage model for kinematics 🟦
            self.hardware_interface = HardwareInterface(self.linkage) # 🟦 Hardware driver interface 🟦

        if self.use_imu:
            self.imu = IMU()            # 🟦 Initialize IMU 🟦

        self.controller = Controller(self.config, four_legs_inverse_kinematics) # 🟦 Main controller logic 🟦
        self.state = State()            # 🟦 Holds robot state 🟦
        self.input_interface = InputInterface(self.config)  # 🟦 Joystick or keyboard input handler 🟦

        rospy.loginfo("Input listener successfully initialised... Robot will now receive commands via Joy messages")

        # 🟦 Print gait configuration 🟦
        rospy.loginfo("Summary of current gait parameters:")
        rospy.loginfo("overlap time: %.2f", self.config.overlap_time)
        rospy.loginfo("swing time: %.2f", self.config.swing_time)
        rospy.loginfo("z clearance: %.2f", self.config.z_clearance)
        rospy.loginfo("back leg x shift: %.2f", self.config.rear_leg_x_shift)
        rospy.loginfo("front leg x shift: %.2f", self.config.front_leg_x_shift)

    def run(self):  # 🟦 Main loop function 🟦
        while not rospy.is_shutdown():
            if self.state.currently_estopped == 1:
```

```
            rospy.logwarn("DingoDriver: E-stop pressed. Controlling code now disabled
until E-stop is released")
            self.state.trotting_active = 0
            while self.state.currently_estopped == 1:
                self.rate.sleep()
            rospy.loginfo("DingoDriver: E-stop released")
            if not self.is_physical:
                self.external_commands_enabled = True
            continue

        if self.external_commands_enabled:
            rospy.loginfo_throttle(5, "DingoDriver: Robot accepting external commands
(TaskSpace/JointSpace).")
        else:
            rospy.loginfo_throttle(5, "DingoDriver: Manual robot control active. Waiting for
InputInterface (Joy messages).")
            if self.input_interface is not None:
                command = self.input_interface.get_command(self.state,
self.message_rate)
                if self.is_physical and command.joystick_control_event == 1:
                    self.external_commands_enabled = True
                    rospy.loginfo("DingoDriver: Joystick requested switch to External
Command Mode.")
                    self.rate.sleep()
                    continue
                self.controller.run(self.state, command)
                self.controller.publish_joint_space_command(self.state.joint_angles)

self.controller.publish_task_space_command(self.state.rotated_foot_locations)
            else:
                rospy.logwarn_throttle(5, "DingoDriver: Manual control attempted but no
InputInterface initialized. Robot will stand still.")
```

```
                self.state.behavior_state = BehaviorState.REST
                self.controller.run(self.state, self.controller.get_default_command())
                self.controller.publish_joint_space_command(self.state.joint_angles)

self.controller.publish_task_space_command(self.state.rotated_foot_locations)

        if self.is_physical and self.use_imu and self.imu is not None:
            self.state.euler_orientation = self.imu.read_orientation()
        else:
            self.state.euler_orientation = np.array([0, 0, 0])

        if self.is_sim:
            self.publish_joints_to_sim(self.state.joint_angles)

        if self.is_physical and self.hardware_interface is not None:
            self.hardware_interface.set_actuator_postions(self.state.joint_angles)

        self.rate.sleep()

    def update_emergency_stop_status(self, msg): # 🟦 Callback to update E-stop 🟦
        if msg.data == 1:
            self.state.currently_estopped = 1
        if msg.data == 0:
            self.state.currently_estopped = 0

    def run_task_space_command(self, msg):  # 🟦 Handle TaskSpace command input
🟦
        if self.external_commands_enabled == 1 and self.state.currently_estopped == 0:
            rospy.loginfo("Received Task Space Command: " + str(msg))
            foot_locations = np.zeros((3, 4))
            foot_locations[0] = [msg.FR_foot.x, msg.FL_foot.x, msg.RR_foot.x, msg.RL_foot.x]
            foot_locations[1] = [msg.FR_foot.y, msg.FL_foot.y, msg.RR_foot.y, msg.RL_foot.y]
```

```
            foot_locations[2] = [msg.FR_foot.z, msg.FL_foot.z, msg.RR_foot.z, msg.RL_foot.z]

            joint_angles = self.controller.inverse_kinematics(foot_locations, self.config)

            if self.is_sim:
                self.publish_joints_to_sim(joint_angles)
            if self.is_physical and self.hardware_interface is not None:
                self.hardware_interface.set_actuator_postions(joint_angles)
        elif self.external_commands_enabled == 0:
            rospy.logerr("ERROR: Robot not accepting commands. Please deactivate manual
control before sending control commands")
        elif self.state.currently_estopped == 1:
            rospy.logerr("ERROR: Robot currently estopped. Please release before trying to
send commands")

    def run_joint_space_command(self, msg):  # 🟦 Handle JointSpace command input
🟦
        if self.external_commands_enabled == 1 and self.state.currently_estopped == 0:
            joint_angles = np.zeros((3,4))
            for i in range(3):
                joint_angles[i] = [msg.FR_foot[i], msg.FL_foot[i], msg.RR_foot[i], msg.RL_foot[i]]
            if self.is_sim:
                self.publish_joints_to_sim(joint_angles)
            if self.is_physical:
                self.hardware_interface.set_actuator_postions(joint_angles)
        elif self.external_commands_enabled == 0:
            rospy.logerr("ERROR: Robot not accepting commands. Please deactivate manual
control before sending control commands")
        elif self.state.currently_estopped == 1:
            rospy.logerr("ERROR: Robot currently estopped. Please release before trying to
send commands")
```

```
    def publish_joints_to_sim(self, joint_angles):  # 🟦 Publish joint angles to Gazebo controllers 🟦
        rows, cols = joint_angles.shape
        i = 0
        for col in range(cols):
            for row in range(rows):
                self.sim_publisher_array[i].publish(joint_angles[row, col])
                i += 1

def signal_handler(sig, frame):  # 🟦 Clean shutdown on Ctrl+C 🟦
    sys.exit(0)

def main():  # 🟦 Entry point 🟦
    rospy.init_node("dingo_driver")
    signal.signal(signal.SIGINT, signal_handler)
    dingo = DingoDriver(is_sim, is_physical, use_imu)
    dingo.run()

main()
```

7. Launch dingo_driver.py:

bash

```
cd ~dingo_ws
catkin_make
source devel/setup.bash
rosrun dingo dingo_driver.py 1 0 0
```

- 1 0 0 means: is_sim=1, is_physical=0, use_imu=0
- Make sure dingo_driver.py is executable or adjust path if needed.

8. Send Task Space Commands

In a new terminal,Use the following command to make the robot move its legs:

bash

```
cd ~dingo_ws
catkin_make
source devel/setup.bash
rostopic pub -r 10 /task_space_cmd dingo_control/TaskSpace
"FR_foot:
  x: 0.1
  y: -0.1
  z: -0.2
FL_foot:
  x: 0.1
  y: 0.1
  z: -0.2
RR_foot:
  x: -0.1
  y: -0.1
  z: -0.2
RL_foot:
  x: -0.1
  y: 0.1
  z: -0.2"
```

🟦 This moves the robot to the specified foot positions using inverse kinematics.

Output: 🎬 dingo moving video.mp4

If You See Controller Errors Like:

```
Could not load controller 'FR_theta1' because controller
type 'effort_controllers/JointPositionController' does not
exist.
```

Fix with:

bash

```
sudo apt install ros-noetic-effort-controllers
ros-noetic-ros-controllers

source /opt/ros/noetic/setup.bash

cd ~/DingoQuadrupeD/dingo_ws

catkin_make

source devel/setup.bash
```