Assignment 2-B
TurtleBot3 Teleop & OLC Analysis

GROUP 1

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GitHub Repository

Overview

- **Teleop:** teleoperate the robot using remote PC keyboard
- **Circle**
    - Move robot in circle with specified constant twist command
    - Radius of circle determined by ratio of linear and angular velocities (kinematic formulation)
    - Wait (delay) 4 seconds for simulation to initialize properly
    - Simulate for robot's one complete traversal around the circle (kinematic formulation)
- **Square**
    - Move robot in square with specified constant twist command
    - Side length of square specified as a constant parameter (0.5 m) in script
    - Wait (delay) 4 seconds for simulation to initialize properly
    - Simulate for robot's one complete traversal around the square (kinematic formulation)
- **Speed variation hypothesis:** as speed increases, trajectory profile will deviate further from ideal

Implementation

- **Robot** | launch `robot` from `turtlebot3_bringup` package
- **Teleop** | run `teleop_keyboard` from `turtlebot3_teleop` package
- **Circle** | argument defaults: `lin_vel = 0.1, ang_vel = 0.1`
  - Launch `circle_node` from `assignment_1c` package
  - Launch `rviz2` from `rviz2` package and load configuration file from `assignment_1c` package
- **Square** | argument defaults: `lin_vel = 0.1, ang_vel = 0.1`
  - Launch `square_node` from `assignment_1c` package
  - Launch `rviz2` from `rviz2` package and load configuration file from `assignment_1c` package
- **Move** | argument defaults: `maneuver = circle, lin_vel = 0.1, ang_vel = 0.1`
  - Launch `circle_node` or `square_node` from `assignment_1c` package depending on `maneuver` argument
  - Launch `rviz2` from `rviz2` package and load configuration file from `assignment_1c` package

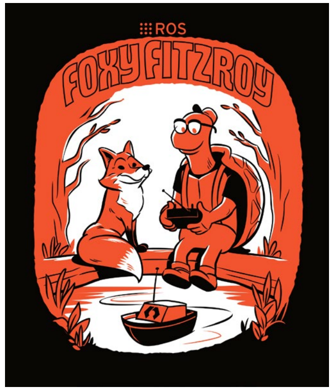
Dependencies

- TurtleBot3 Burger Robot Hardware with TurtleBot3 SBC Image
- ROS2 Foxy Fitzroy on Ubuntu 20.04 Focal Fossa
- TurtleBot3 Packages - Included with the assignment repository
- TurtleBot3 Simulations Packages - Included with the assignment repository
- TurtleBot3 Messages Package - Included with the assignment repository
- TurtleBot3 Dynamixel SDK Packages - Included with the assignment repository

20.04 LTS

Source: Ubuntu

Source: ROS2 GitHub



Source: ROS2 Docs

GAZEBO

Source: GazeboSim

TURTLEBOT3

Source: ROBOTIS Inc.

Build Instructions

- Make a directory **`ROS2_WS`** to act as your ROS2 workspace.
- Clone the assignment repository.
- Move **`assignment_1c`** directory to **`src`** of your **`ROS2_WS`**.
- [Optional] Remove the unnecessary files.
- Build the packages.
- Source the **`setup.bash`** file of your **`ROS2_WS`**.
- **NOTE:** Detailed instructions are available in README.md file of the assignment repository.

Build:

1. Make a directory `ROS2_WS` to act as your ROS2 workspace.

```
$ mkdir -p ~/ROS2_WS/src/
```

2. Clone this repository:

```
$ git clone https://github.com/Tinker-Twins/Autonomy-Science-And-Systems.git
```

3. Move `assignment_2b` directory with required ROS2 packages to the source space (`src`) of your `ROS2_WS` .

```
$ mv ~/Autonomy-Science-And-Systems/Assignment\ 2-B/assignment_2b/ ~/ROS2_WS/src/
```

4. [Optional] Remove the unnecessary files.

```
$ sudo rm -r Autonomy-Science-And-Systems
```

5. Build the packages.

```
$ cd ~/ROS2_WS
$ colcon build
```

6. Source the `setup.bash` file of your `ROS2_WS` .

```
$ echo "source ~/ROS2_WS/install/setup.bash" >> ~/.bashrc
$ source ~/.bashrc
```

Source: Tinker Twins GitHub

Execution Instructions

- **Robot:** Launch `robot.launch.py` file from `turtlebot_bringup` package
- **Teleop:** Run `teleop_keyboard` executable from `turtlebot3_teleop` package
- **Circle**
  - Launch `circle.launch.py` file from `assignment_1c` package
  - Provide arguments for `lin_vel` and `ang_vel` (float)
- **Square**
  - Launch `square.launch.py` file from `assignment_1c` package
  - Provide arguments for `lin_vel` and `ang_vel` (float)
- **Move**
  - Launch `move.launch.py` file from `assignment_1c` package
  - Provide argument for `maneuver` (string)
  - Provide arguments for `lin_vel` and `ang_vel` (float)

NOTE: Detailed instructions are available in README.md file of the assignment repository.

Execute:

1. Connect to the TurtleBot3 SBC via Secure Shell Protocol (SSH):

```
$ sudo ssh <username>@<ip.address.of.turtlebot3>
$ sudo ssh ubuntu@192.168.1.87
```

2. Bringup TurtleBot3:

```
$ ros2 launch turtlebot3_bringup robot.launch.py
```

3. Teleoperation using Keyboard:

```
$ ros2 run turtlebot3_teleop teleop_keyboard
```

4. Open-Loop Circle (twist commands specified by the user):

```
$ ros2 launch assignment_2b circle.launch.py lin_vel:=0.15 ang_vel:=0.15
```

5. Open-Loop Square (twist commands specified by the user):

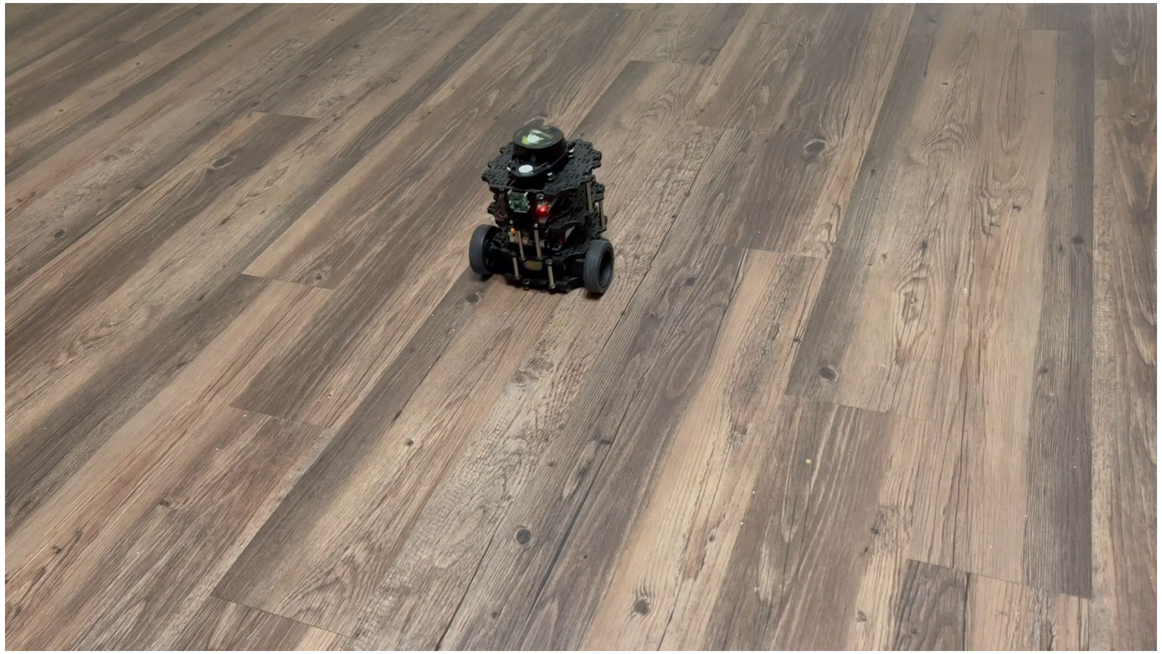
```
$ ros2 launch assignment_2b square.launch.py lin_vel:=0.15 ang_vel:=0.15
```

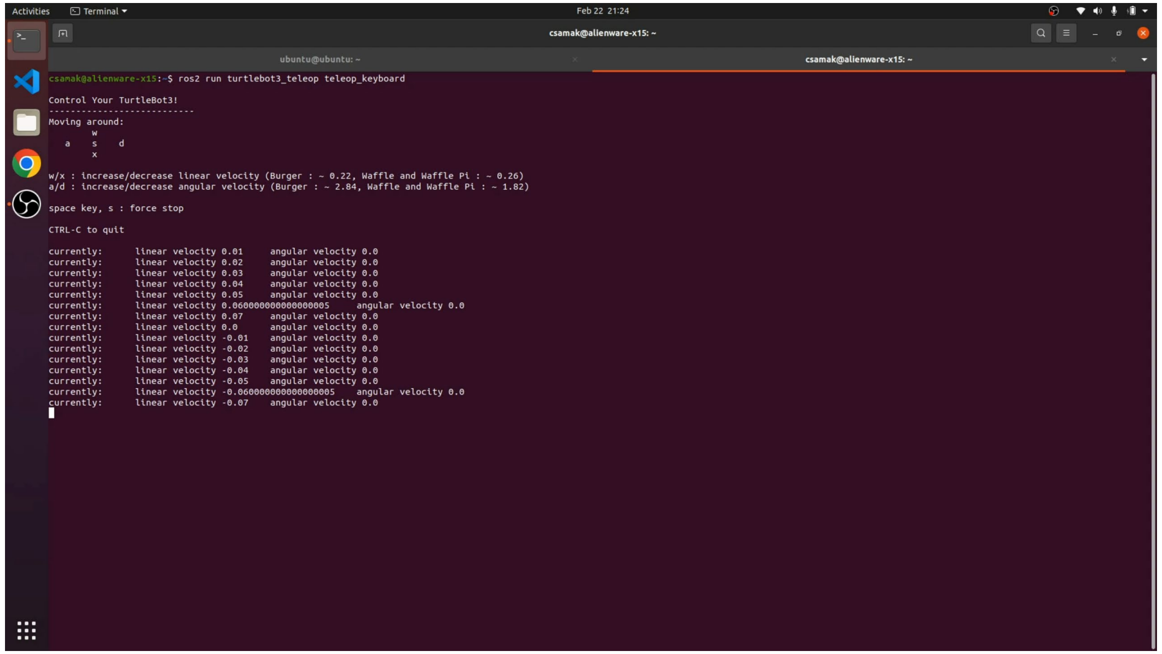
6. Open-Loop Move (square or circle maneuver with twist commands specified by the user):

```
$ ros2 launch assignment_2b move.launch.py maneuver:=circle lin_vel:=0.15 ang_vel:=0.15
$ ros2 launch assignment_2b move.launch.py maneuver:=square lin_vel:=0.15 ang_vel:=0.15
```

Source: Tinker Twins GitHub

Results - Teleop



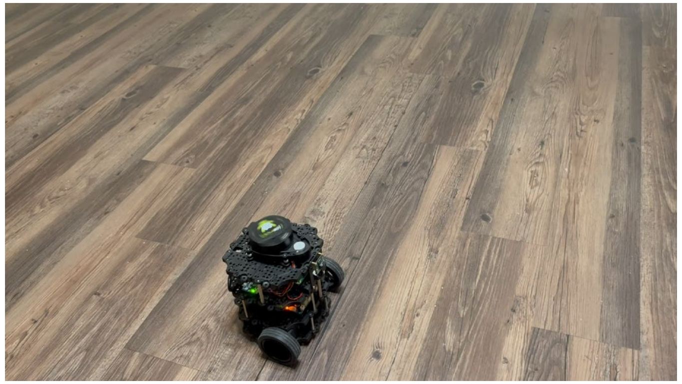


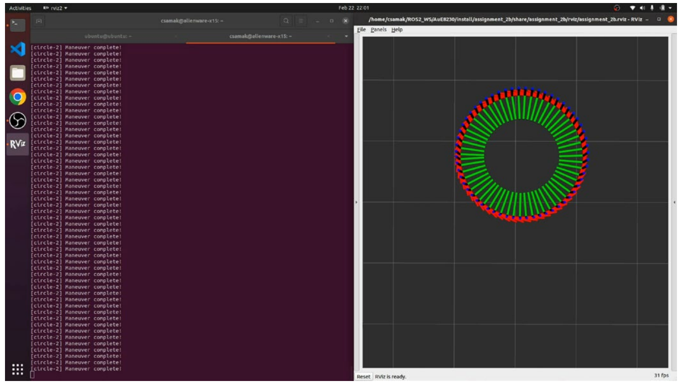
Results - Circle

Robot

RViz

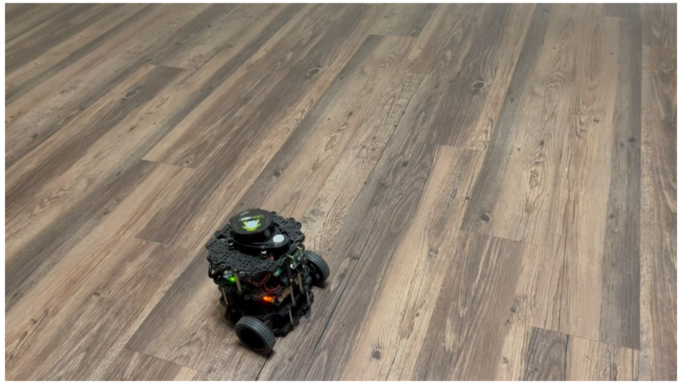
Slow

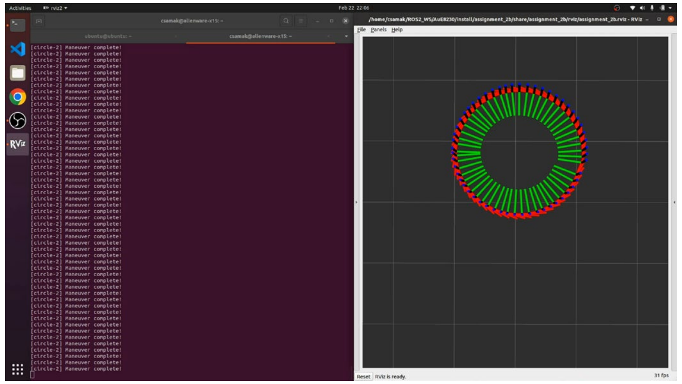




$v = 0.05, \omega = 0.2$

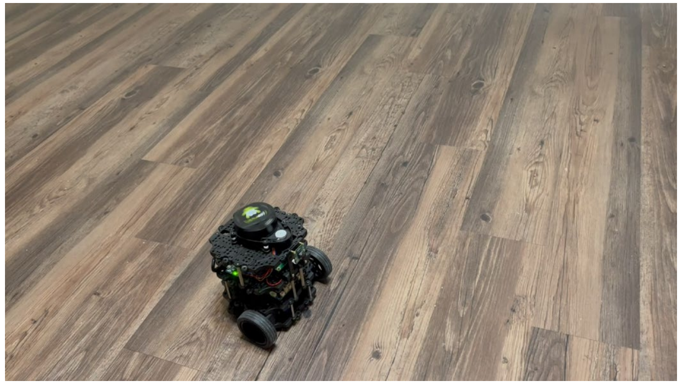
Medium

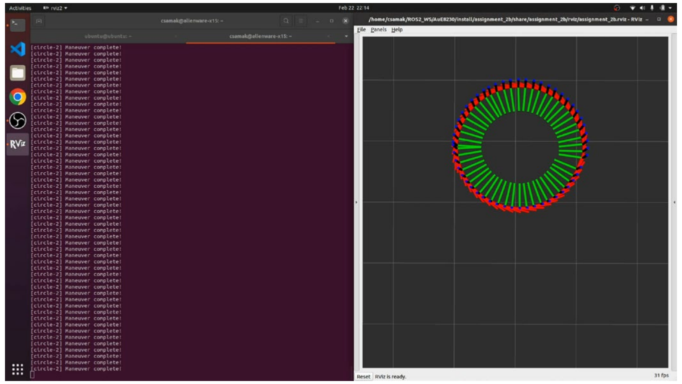




$v = 0.10, \omega = 0.4$

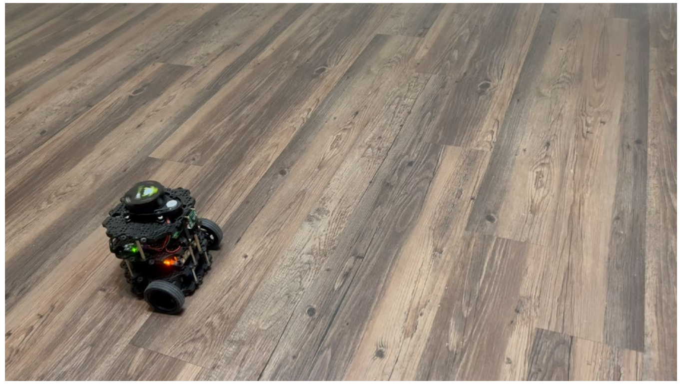
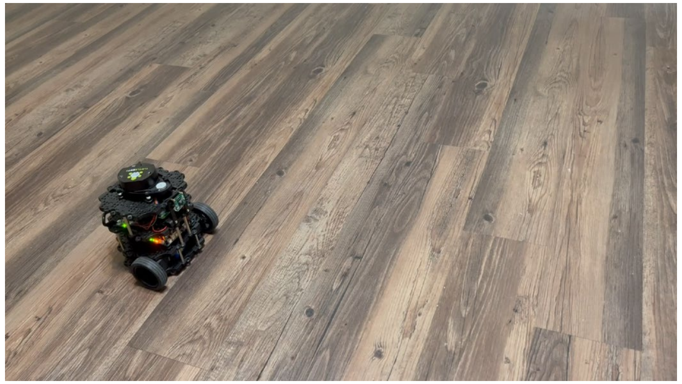
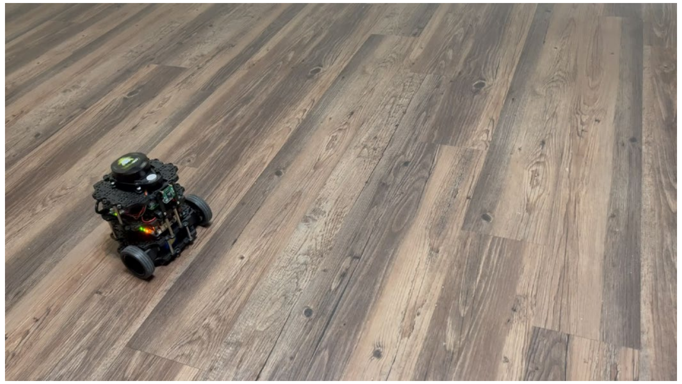
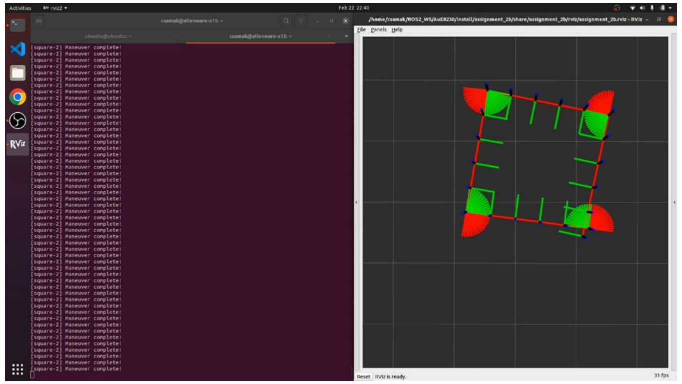
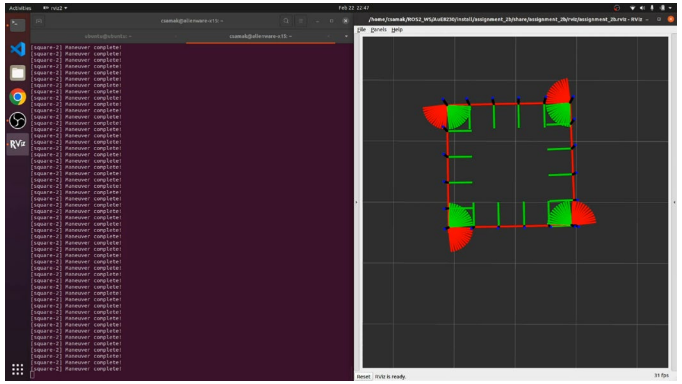
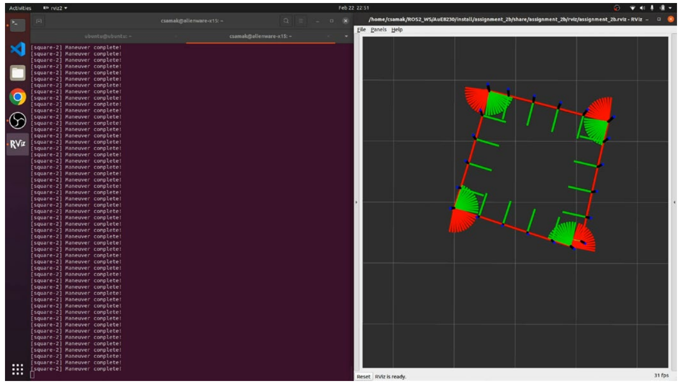
Fast





$v = 0.15, \omega = 0.6$

Results - Square

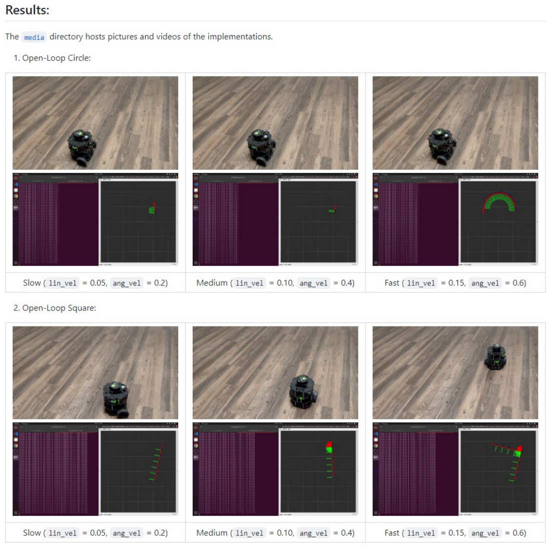
	Slow	Medium	Fast
Robot			
RViz			
	$v = 0.05, \omega = 0.2$	$v = 0.10, \omega = 0.4$	$v = 0.15, \omega = 0.6$

Analysis

Parameter/Metric	Slow Circle	Slow Square	Medium Circle	Medium Square	Fast Circle	Fast Square
Resemblance to ideal trajectory	Very High	Low	High	Medium	Medium	Extremely Low
Kinematic behavior	Very High	High	High	Medium	Medium	Very Low
Time for 1 complete traversal	High	Very High	Medium	Medium	Very Low	Low

Note 1: The analysis presented above is qualitative.
Although a detailed quantitative analysis can be accomplished, it was beyond the scope of this assignment.

Note 2: Deployment videos as well as pictures are available in README.md file as well as in the media directory of the assignment repository.



Source: Tinker Twins GitHub

Thank You!