ENPM 662 - Introduction to Robot Modeling
PROJECT -1
CAD Modeling & Simulation using Gazebo

GROUP - 22

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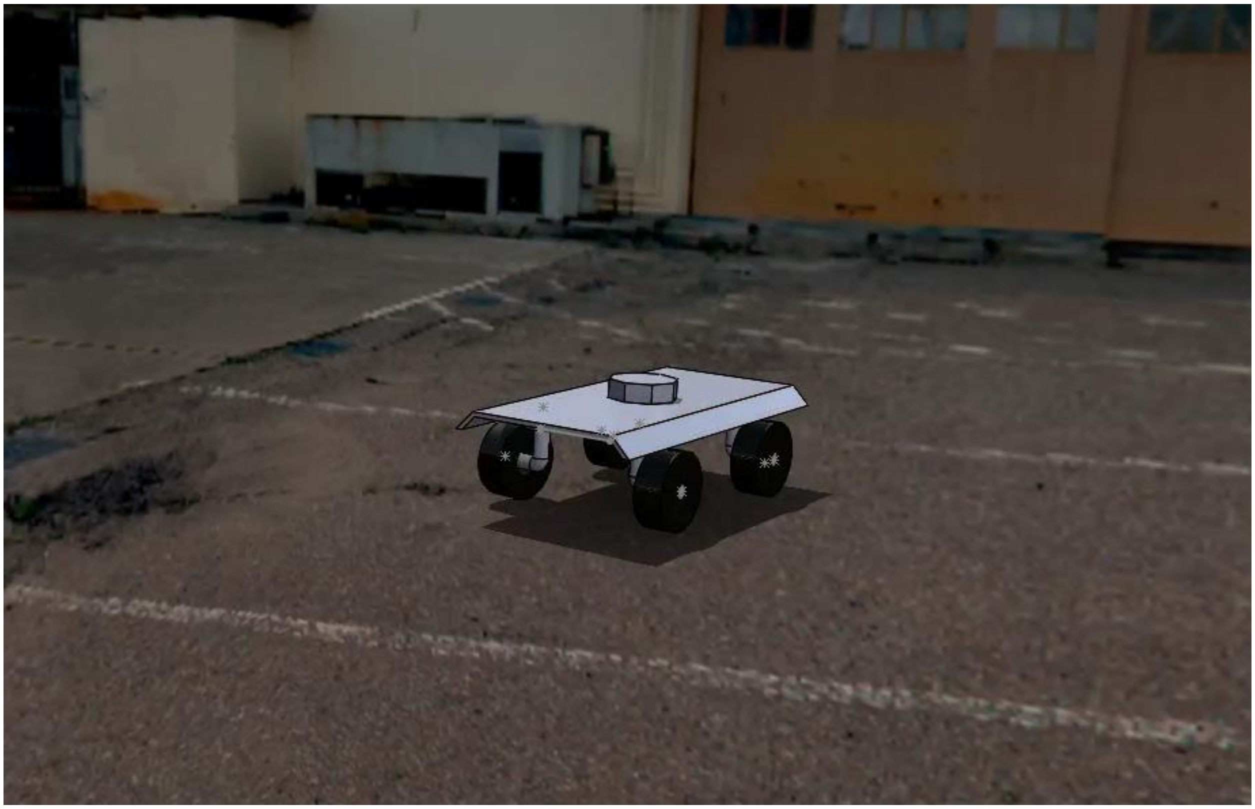
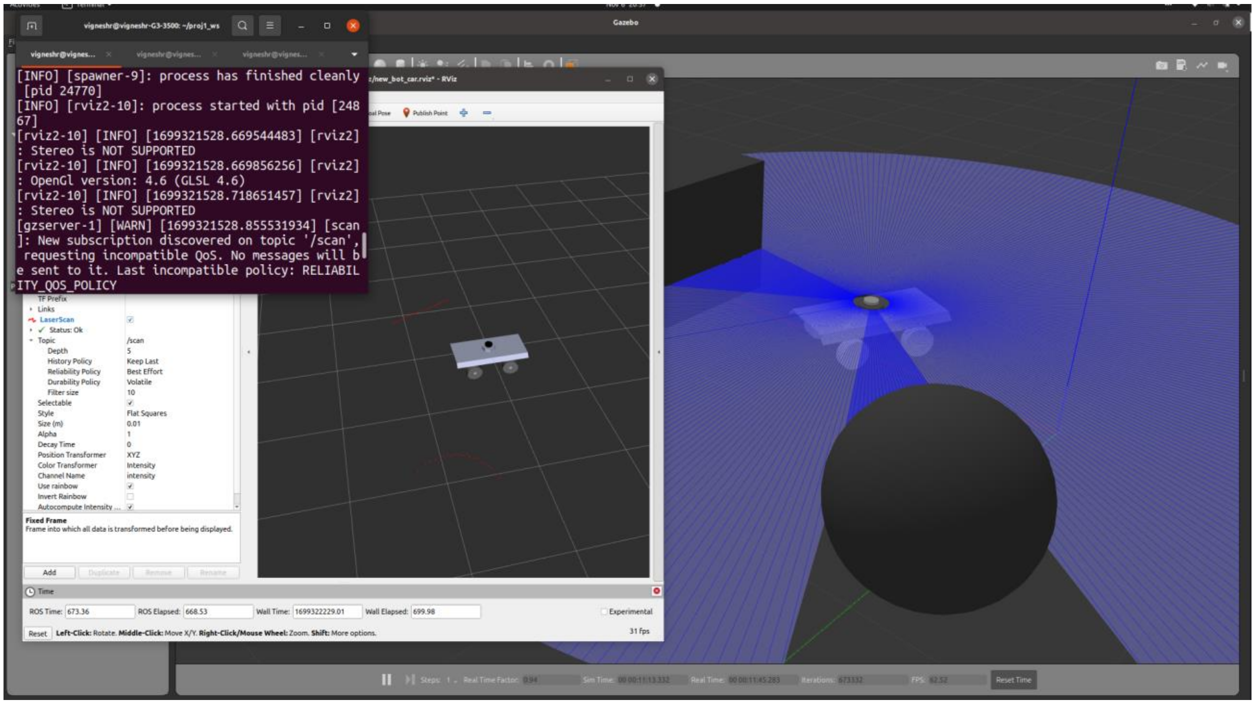
The toy car - SolidWorks Design:



RVIZ + Gazebo (debug launch)



```
[INFO] [spawner-9]: process has finished cleanly
 [pid 24770]
[INFO] [rviz2-10]: process started with pid [248
67]
[rviz2-10] [INFO] [1699321528.669544483] [rviz2]
: Stereo is NOT SUPPORTED
[rviz2-10] [INFO] [1699321528.669856256] [rviz2]
: OpenGl version: 4.6 (GLSL 4.6)
[rviz2-10] [INFO] [1699321528.718651457] [rviz2]
: Stereo is NOT SUPPORTED
[gzserver-1] [WARN] [1699321528.855531934] [scan
]: New subscription discovered on topic '/scan',
 requesting incompatible QoS. No messages will b
e sent to it. Last incompatible policy: RELIABIL
ITY_QOS_POLICY
```

TF Prefix
Links
LaserScan ☑
Status: Ok
Topic /scan
Depth 5
History Policy Keep Last
Reliability Policy Best Effort
Durability Policy Volatile
Filter size 10
Selectable ☑
Style Flat Squares
Size (m) 0.01
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer Intensity
Channel Name intensity
Use rainbow ☑
Invert Rainbow ☐
Autocompute Intensity ... ☑

Fixed Frame
Frame into which all data is transformed before being displayed.

Time

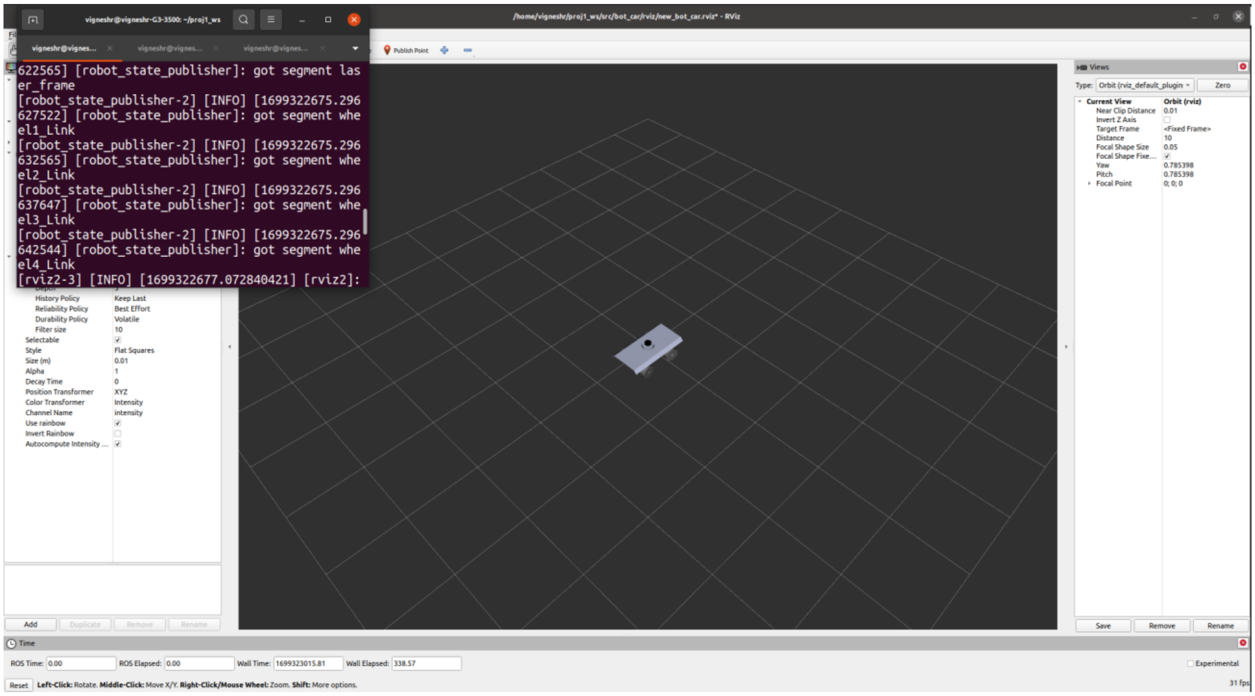
ROS Time: 673.36 ROS Elapsed: 668.53 Wall Time: 1699322229.01 Wall Elapsed: 699.98 ☐ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:** Zoom. **Shift:** More options. 31 fps

Steps: 1 Real Time Factor: 0.94 Sim Time: 00 00:11:13.332 Real Time: 00 00:11:45.283 Iterations: 673332 FPS: 62.52

- The lidar point cloud can be seen from RviZ window.

Display Launch (RViz)


vigneshr@vigneshr-G3-3500: ~/proj1_ws
/home/vigneshr/proj1_ws/src/bot_car/rviz/new_bot_car.rviz* - RViz
Publish Point
Views
Add
Duplicate
Remove
Rename
Save
Remove
Rename
Time
Reset

```
622565] [robot_state_publisher]: got segment las
er_frame
[robot_state_publisher-2] [INFO] [1699322675.296
627522] [robot_state_publisher]: got segment whe
el1_Link
[robot_state_publisher-2] [INFO] [1699322675.296
632565] [robot_state_publisher]: got segment whe
el2_Link
[robot_state_publisher-2] [INFO] [1699322675.296
637647] [robot_state_publisher]: got segment whe
el3_Link
[robot_state_publisher-2] [INFO] [1699322675.296
642544] [robot_state_publisher]: got segment whe
el4_Link
[rviz2-3] [INFO] [1699322677.072840421] [rviz2]:
```

History Policy: Keep Last
Reliability Policy: Best Effort
Durability Policy: Volatile
Filter size: 10
Selectable: ☑
Style: Flat Squares
Size (m): 0.01
Alpha: 1
Decay Time: 0
Position Transformer: XYZ
Color Transformer: Intensity
Channel Name: intensity
Use rainbow: ☑
Invert Rainbow: □
Autocompute Intensity ...: ☑

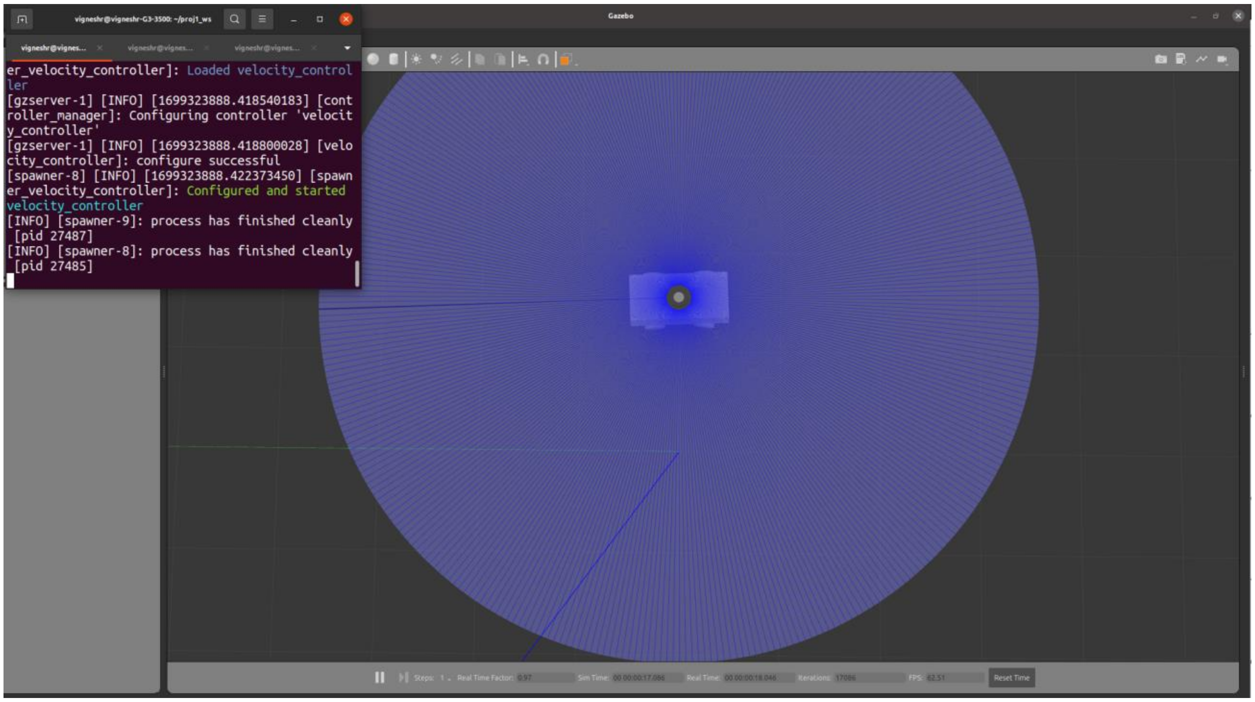
Type: Orbit (rviz_default_plugin Zero

Current View: Orbit (rviz)
Near Clip Distance: 0.01
Invert Z Axis: □
Target Frame: <Fixed Frame>
Distance: 10
Focal Shape Size: 0.05
Focal Shape Fixe...: ☑
Yaw: 0.785398
Pitch: 0.785398
Focal Point: 0; 0; 0

ROS Time: 0.00 ROS Elapsed: 0.00 Wall Time: 1699323015.81 Wall Elapsed: 338.57 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:** Zoom. **Shift:** More options. 31 fps

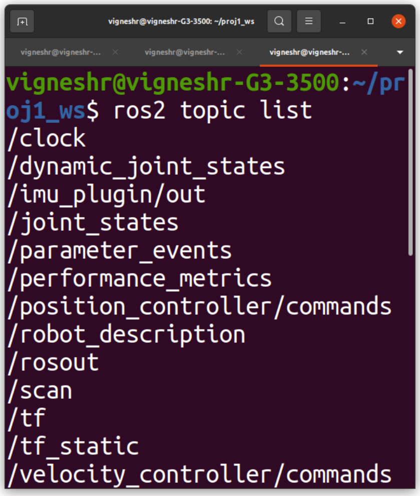
Gazebo Launch



```
er_velocity_controller]: Loaded velocity_control
ler
[gzserver-1] [INFO] [1699323888.418540183] [cont
roller_manager]: Configuring controller 'velocit
y_controller'
[gzserver-1] [INFO] [1699323888.418800028] [velo
city_controller]: configure successful
[spawner-8] [INFO] [1699323888.422373450] [spawn
er_velocity_controller]: Configured and started
velocity_controller
[INFO] [spawner-9]: process has finished cleanly
 [pid 27487]
[INFO] [spawner-8]: process has finished cleanly
 [pid 27485]
```

Steps: 1 Real Time Factor: 0.97 Sim Time: 00 00:00:17.086 Real Time: 00 00:00:18.046 Iterations: 17086 FPS: 62.51

IMU



```
vigneshr@vigneshr-G3-3500:~/pr
oj1_ws$ ros2 topic list
/clock
/dynamic_joint_states
/imu_plugin/out
/joint_states
/parameter_events
/performance_metrics
/position_controller/commands
/robot_description
/rosout
/scan
/tf
/tf_static
/velocity_controller/commands
```

Proportional Controller video - https://drive.google.com/file/d/1NddSCaMZkE8h26zbAMu6gI7rXL7g0Pbs/view?usp=sharing

Teleop_video: https://drive.google.com/file/d/1i03OpD7FzxXEtRpz4F1r43B8kfrjL7zk/view?usp=drive_link

Challenges:

1. Proportional controllers encountered significant challenges when attempting to maintain control and guide the robot from its initial state to the desired goal position. These difficulties stemmed from the limitations of the IMU, which was unable to furnish pose values. In the absence of precise information regarding the robot's position and orientation, the task of effectively controlling its movements with closed loop proportional controller became notably complex.
2. There were issues with the model spawning in Gazebo – it turned out to be rotated by a certain angle and dropped from a certain height, which caused it to lose balance and even dissemble a few times.
3. Getting the car's wheels to work smoothly together took a lot of tinkering. It was a real challenge to make the physical parts and the computer programs work together, especially when it came to how the wheels turned.
4. Both the packages (pubsub and bot_car) were created separately because the dependencies were different.

Personal Contribution:

1. **Spawning issues on Gazebo :** There were issues with the model spawning in Gazebo – it turned out to be rotated 180 degrees, so had to correct that.
2. **Writing the publisher and subscriber** : Publisher was written to publish velocities and angular values to the joints of the robot. Subscriber was written to get the data from IMU to know the angular velocities and orientation of the car.
3. **Designed the proportional controller**: Ran the package multiple times for Kp value tuning and velocity updation. The data from subscriber node was used in order to publish the values.
4. **Tuning :** Multiple iterations were run in order to get the car to move in the right direction with right velocity.
5. **Error with revolute joints :** There was an error with defining axel links as revolute joints, the robot appeared disconnected from the shafts on gazebo due to error in URDF. This was fixed using continuous joints instead.

Improvements:

- A few issues with the robot wheel friction arised while simulating in Gazebo. An inherent skid was observed during the movement. This project can be further enhanced by defining a good amount of friction to the wheels of the robot with the ground, so that the movement is accurate.
- Further improvement can be done by properly defining the material for the robot.
-To resolve the problem of the IMU not supplying pose data, one potential solution is to incorporate a specialized pose sensor or upgrade the sensor array by adding a GPS module. This enhancement would offer the precise global positioning information required to improve the proportional controller's performance.