# Introduction to Robot Modeling
# ENPM 662

**Project 1** - CAD Modeling &
Simulation using Gazebo

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Submitted on:
11/06/2023

**Objective:** CAD modeling and simulation using GAZEBO

## Project goals:

- To build a toy car in solidworks and export it as a URDF file.
- Adding a Lidar sensor modules to the car model and visualize in Rviz and Gazebo.
- Performing Teleop in the competition setup.
- Moving the car from [0,0] to [10,10] using closed loop controller.

## Understanding:

- Modeled toy car in solidworks and assembled it.
- Exported URDF file , and added position and velocity controller data of respective joints, LIDAR data and IMU to it.
- Created a .yaml file and added the controllers data to it.
- Used the given launch files to spawn the robot in gazebo and Rviz, added lidar data and visualized it.
- Moved the car inside the competition setup using teleop script, then using proportional controller, driven the car from [0,0] to [10,10].

## Problems faced:

- For Joints and wheels., the axes and coordinate frames that were automatically generated with URDF exporter were incorrect and the car was not spawning correctly in the gazebo, so manually defined the axes and coordinate frames.
- LIDAR sensor visualization was inside the car, so figured out that the coordinate frame's position was the issue and increased its height.
- Errors in RViz, such as missing link transforms, were observed despite correct robot spawning in Gazebo. These issues were traced back to inaccurate axis definitions in the URDF file. Reconstructing the URDF, assigning precise reference axes to the joints, rectified the joint definition inaccuracies. As a result, the robot appeared correctly in both Gazebo and Rviz.
- In the ROS2 environment, a warning was encountered indicating an incompatible QoS profile for the 'imu_plugin/out' topic with a previous QoS policy. This issue was resolved by manually specifying the QoS profile in the script using a BEST_EFFORT reliability policy and a KEEP_LAST history policy. The QoS profile was then applied when subscribing to the 'imu_plugin/out' topic, ensuring that the QoS settings matched between the publisher and the subscriber, resolving the compatibility issue.

## Contributions:

- Designed and assembled the robot/toy car in SolidWorks, aligning with project design requirements.
- Exported the robot's design to URDF format using the SW2URDF Exporter tool for ROS 2 compatibility.
- Integrated LiDAR sensor into the robot's design for enhanced perception capabilities.

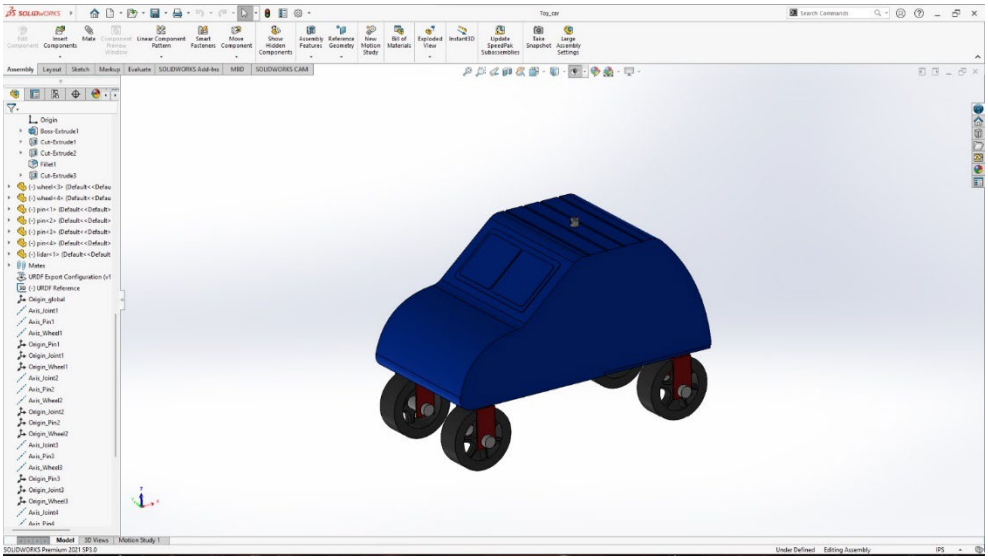
- Successfully executed a teleoperation script to navigate the robot through a competition setup, completing a full lap.

## Improvements:

The method for driving the robot from (0,0) to (10,10) has not been mentioned explicitly in the documentation.

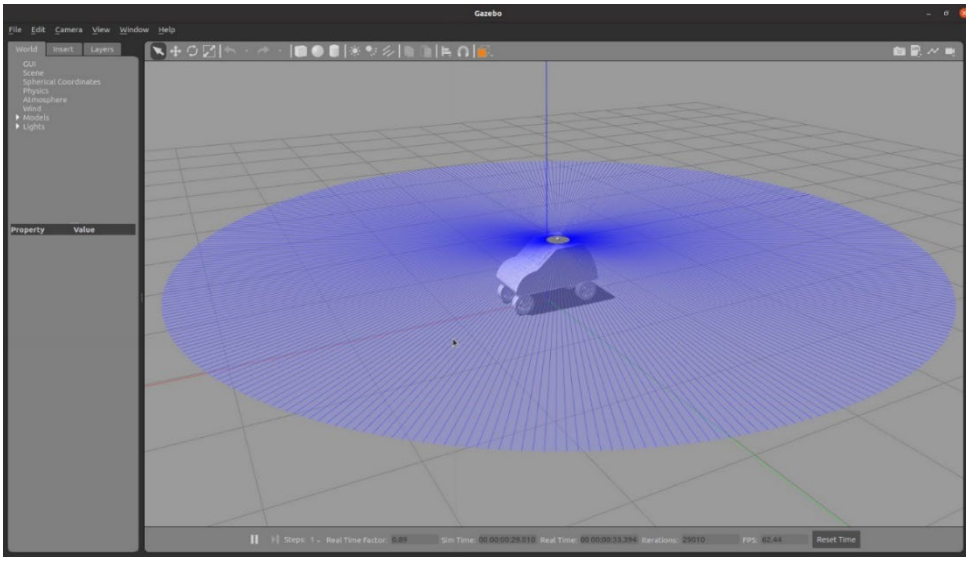
## SolidWorks:

The toy car has been designed in SolidWorks using the given design requirements. On top of the chassis, a LiDAR sensor is added.



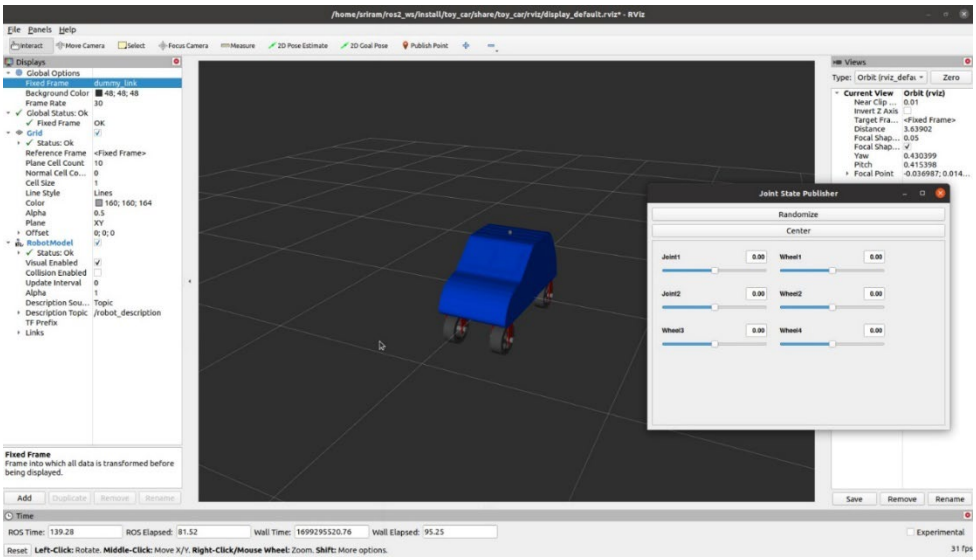
## Gazebo Launch:

The robot has been spawned in the gazebo environment using “ros2 launch toy_car gazebo.launch.py” command in the terminal.



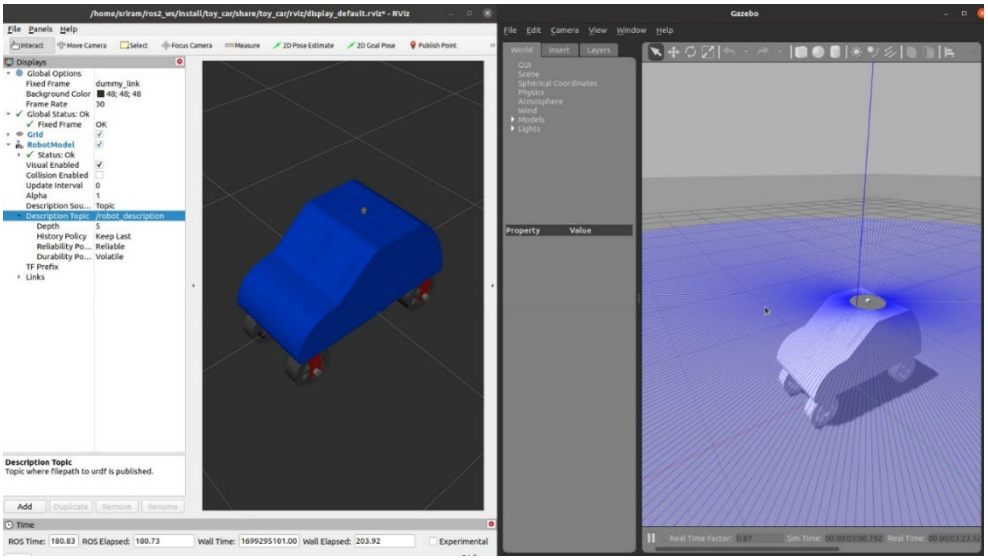
## Display/ Rviz Launch:

The robot has been spawned in the Rviz environment using “ros2 launch toy_car display.launch.py” command in the terminal.



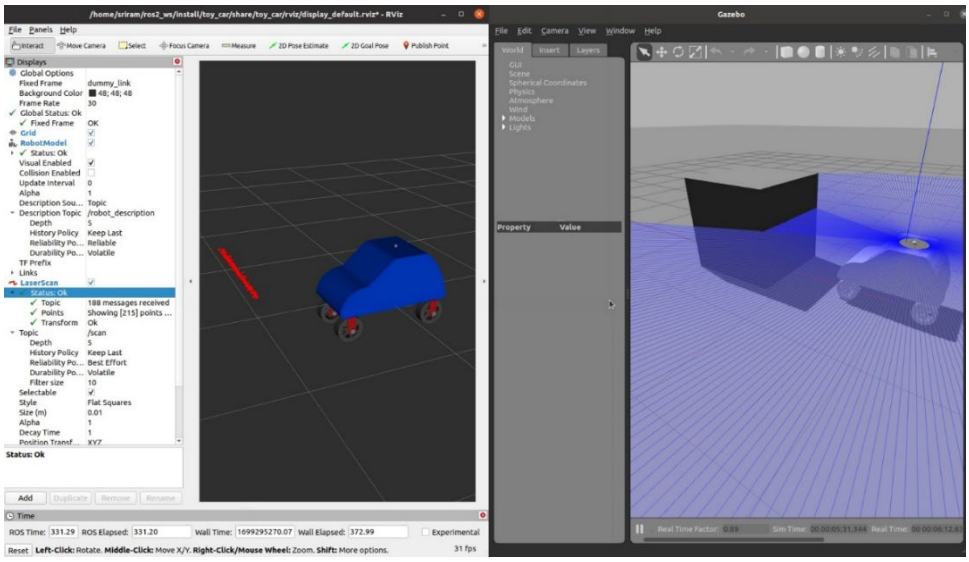
## Debug Launch:

The robot has been spawned in both Gazebo and Rviz environment simultaneously using “ros2 launch toy_car debug.launch.py” command in the terminal.



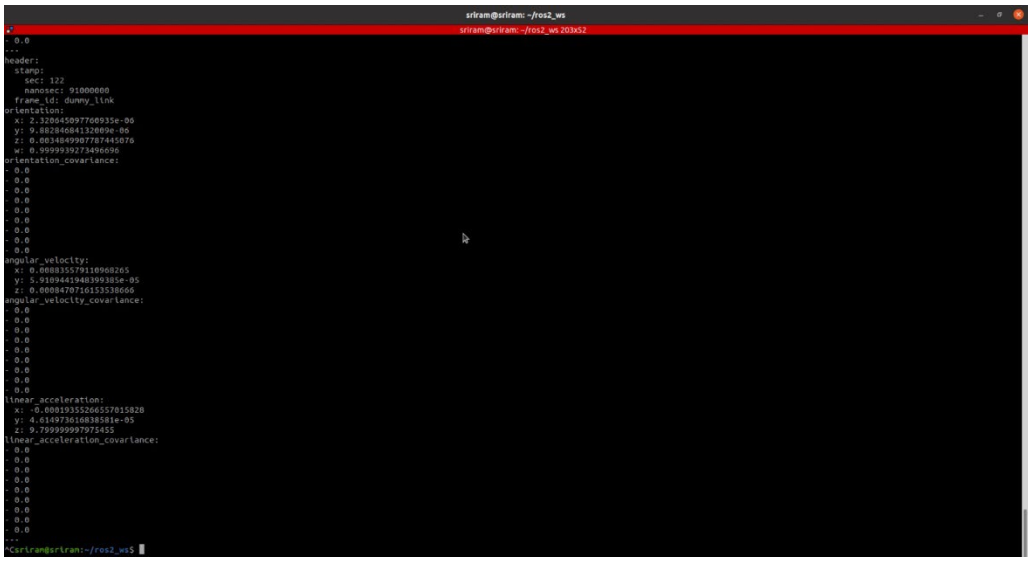
## LiDAR:

The functionality of the LiDAR is observed by introducing obstacles in the environment.




## Inertial Measurement Unit (IMU):

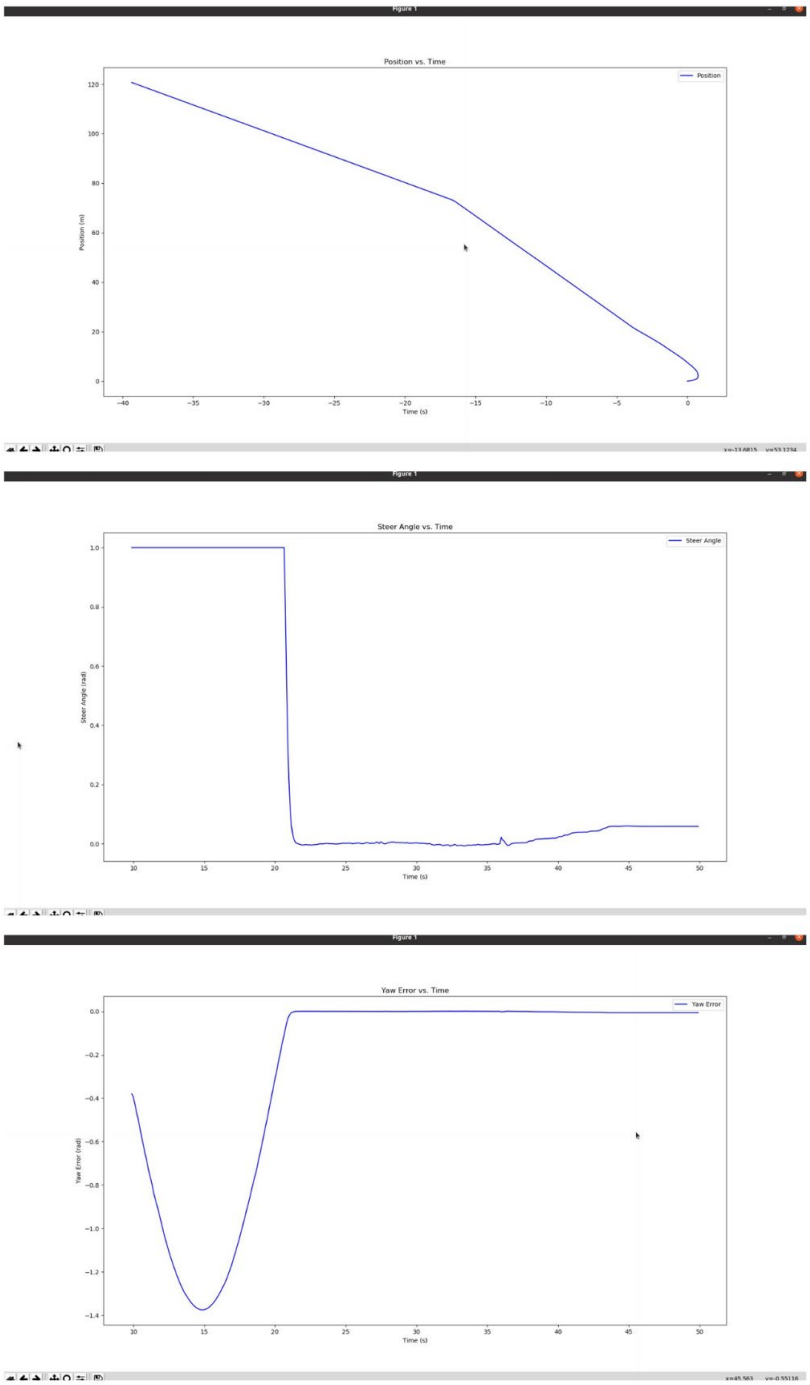
The functionality of the IMU is observed as it is subscribing to the robot's data.



## Proportional Controller:

The link below contains the video of the robot moving from A (0,0) to B (10,10).

https://drive.google.com/file/d/1JutA0L2NpVbp9G4MeJvpsdbmqqcM7HtV/view?usp=sharing




a) Position vs Time plot b) Steer angle (control) vs Time plot c) Yaw error vs Time plot

## Teleoperation in Competition setup:

The below link contains the video of the robot being teleoperated in the competition setup.

https://drive.google.com/file/d/141weB6x8F-j0YxN88nPRulcDrmmHv0vg/view?usp=sharing