ENPM 662: Introduction to Robot Modeling

Project 1: CAD Modeling & Simulation using Gazebo.

Due Date: 11:59 pm 2th November 2024

Project Goals

- Build a specific robot model on SolidWorks and export it as URDF.
- Add LiDAR Sensor on to your robot and show your visualization (LiDAR points) in RViz.
- Perform teleop and move around in the map in Gazebo.
- Code up a simple proportional controller for your robot to move from point A (0,0) to point B(10,10). The robot is initially aligned with either the x-axis or y-axis.

All the instructions required for successfully completing the above goals can be found here.

Project Workflow

Read the below workflow to guide yourself to complete the project.

1. Build a Model on Solidworks.
2. Converting Package to be compatible with ROS2.
3. Add Controllers and Laser to your Robot.
4. Run Teleop.
5. Write a simple Proportional Controller.

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1 Build a model on Solidworks.

Download and Install Solidworks

To install Solidworks (for Windows) from here or Citrix Workspace (for Wondows or Linux) from here. It's free for UMD students (instructions will be on the same page and would be visible after you login).

Download and URDF Exporter Tool

You can download the URDF exporter from here (If you're using Citrix Workspace then you don't have to download the urdf exported tool since its already included with the software). A brief description of what this is as mentioned on their webpage : The SolidWorks to URDF exporter is a SolidWorks add-in that allows for the convenient export of SW Parts and Assemblies into a URDF file. The exporter will create a ROS-like package that contains a directory for meshes, textures and robots (urdf files). For single SolidWorks parts, the part exporter will pull the material properties and create a single link in the URDF. For assemblies, the exporter will build the links and create a tree based on the SW assembly hierarchy. The exporter can automatically determine the proper joint type, joint transforms, and axes.

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Build your CAD Model

Use the specs mentioned in here to build a 3D model of the Robot. Build individual CAD models of each part (chassis, wheel, trailer, etc.) and then assemble them in a single file. You could refer the following tutorials videos here, here and here.

Export as URDF

Use the URDF exporter tool to define parent, child links. The tool automatically determines the axis between joints and sets origins for different links that are defined. Though sometimes the automatic axis generation might not be ideal, we can rotate the coordinate frames while exporting the URDF as well. Export the URDF along with meshes. To help with this process, you could refer this video.

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2 Converting the Package to be compatible with ROS2.

The package that is exported by the SW2URDF Exporter works well with ROS1. However, to make this package compatible with ROS2 we need to make a few changes in the package that is generated.
Get a detailed explanation about this process here.

3 Add Controllers and Laser to your Robot.

Now that we have made our package compatible with ROS2 we can now add controllers to our robot to move the joints.
Get the detailed explanation about adding controller to your robot here.
For instructions to add LiDar to your model follow this link.

4 Run Teleop

As we have now installed the controllers on our robot, we can use a teleop script to control the robot. Using the Teleop script complete a lap in the competition world. Check this link to get information on how to download and run the teleop

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5 Write a simple publisher-subscriber.

Navigate to this (python) link and understand how publishers and subscribers work in ROS2. The above link is a part of the ROS2 tutorials series which assumes that you have completed stuff in that tutorial series from the beginning. If you have not done that already during Project 0 then navigate to this link and follow along the tutorial. Then code up a simple publisher which will publish commands to drive your robot in a straight line using a proportional controller. You can launch your robot in an empty gazebo world for this task since empty gazebo world would have lots of empty space to drive your robot. The robot should move from point A(0,0) to pointB(10,10).

Appendix

Few useful Links:

- URDF vs XACRO
- Understand xacro file structures
- Example of complicated Xacro file
- Understanding gazebo plugins

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Robot Specifications:

- Front two wheel need to be steerable. Make sure both the wheels steer independently.

  Do not use a Differential Drive or Ackermann Steering.

- Full length of chassis (Longitudinal) - 38 inches.
- Breadth of chassis (Lateral) - 20 inches.
- Wheelbase - 20 inches.
- Wheel thickness - 3 inches.
- Wheel diameter - 8 inches.
- Trailer dimensions are optional
- Add a cylindrical extrusion on the top of your chassis. This will be an independent cylindrical link on which we will be adding the LiDAR sensor.

(The specifications given above need not be the exact value, but it should be close to the given value and certainly not bigger than above values)

Submission Guidelines:

In this project, you need to submit your project in the following structure:

A zip file with the name **YourDirectoryID_Proj1.zip** on to ELMS/Canvas. A main folder with the name **YourDirectoryID_Project1** and the following sub-folders/files:

1- Package : A folder containing all your main files which you need to put into ROS Workspace in order to make it run. Do not add the workspace, just the package. Once you've exported your package from SolidWorks, upload it to GitHub and make all subsequent changes there to ensure everything is trackable. Please keep your repository private and add the instructor and grader as collaborators. All team members are expected to contribute and commit to the repository. Trackable changes will enable the instructor and grader to evaluate each member's individual contributions. You should upload your package to Canvas and provide a link to your GitHub account.

2- Assembly: An external assembly.zip file containing the assembly file and parts (the .STLPRT files) should be uploaded to Canvas.

3- Videos: Two videos are required as submission:

1. *Teleoperation mode:* Video of robot driven by teleop from the checkpoint on the track (in Gazebo) and completing 1 lap of the track. You must start recording the video before you launch your model in Gazebo world i.e. you have to show the process of launching your model and

also the teleop terminal in the video.

2. *Autonomous mode:* Video of robot driven by the commands from the publisher (in a straight line) using a proportional controller to move from point A(0,0) to point B(10,10). For this video, start recording, then launch your package again from beginning, then launch publisher and subscriber nodes in separate terminals and show your robot moving in the Gazebo world for 10~15 seconds and then show terminals for both publisher and subscriber (the publisher should show publishing commands and subscriber should show subscribing to them).

4- Plot pose using subscription method

5- Report: Your report should be in PDF format and no more than 1-2 pages include figures from RVIZ visualization (LiDAR Sensor), and pose plot using subscription method for the Autonomous mode. You do not need to explain the data in the document in detail. Just concentrate on the steps and process you followed to make this project work. Also, any problems you faced during the process and discuss the results you have obtained. The report should also have links to the videos described below.