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Wall Following Robot Project

Introduction

Overview

Build a robot application that identifies the wall/obstacles and the robot has to follow along the identified wall for a certain distance. It should stop whenever it doesn't recognize the wall/obstacle. The robot will collect the wall/obstacle info from the laser distance sensor.

Develop a simulation application using URDF and Xacro modeling techniques, that modeled robot will load inside the Gazebo simulator world. The Gazebo world will be created with SDF techniques in the ROS. With the help of Gazebo plug-ins, we will control the robot, and also we will get the Laser Distance Sensor data. It receives the input from the robot application for following the modeled robot along the walls inside the simulator.

Test the wall following algorithm in the Gazebo Simulator. It collects the inputs from the laser distance sensor and shows the wall following the result on the Gazebo simulator. It uses both the robot application and simulation application to get the result on the Gazebo simulator.

Purpose

You'll be able to work with the most powerful open-source robotics framework i.e. ROS(Robot Operating System),

You'll be in a position to create ROS packages for Robot applications and Simulation applications,

Simulating the robot on Gazebo simulator by considering real environment parameters

Getting laser scan values inside the Gazebo simulator with python.

Building a robot that can move autonomously by following the wall

Literature Survey

Existing problem

Robots are still not able to navigate through obstacles in their path. Even if a robot is trained to understand its environment, the slightest of alterations require the robots to re-learn and adapt to new environments. This can possibly lead to delays in carrying out the assigned tasks or even cause accidents. Machine learning and computer vision technologies are currently being leveraged to overcome the mapping challenge. However, these technologies aren't foolproof and function best only under controlled environments. Additionally, real-life scenarios are highly unpredictable. No matter how trained the robot is or how good its adaptability to new environments, there always arises a situation for which the robot is not prepared for.

Proposed solution

Obstacles/wall following robots are widely used in industrial applications. Here we are going to build a robot application that follows the walls in the simulator. It recognizes the one laser distance and it follows along the wall. The whole project is developed with the ROS framework. The final robot is tested on the Gazebo simulator.

Theoretical Analysis

Block diagram

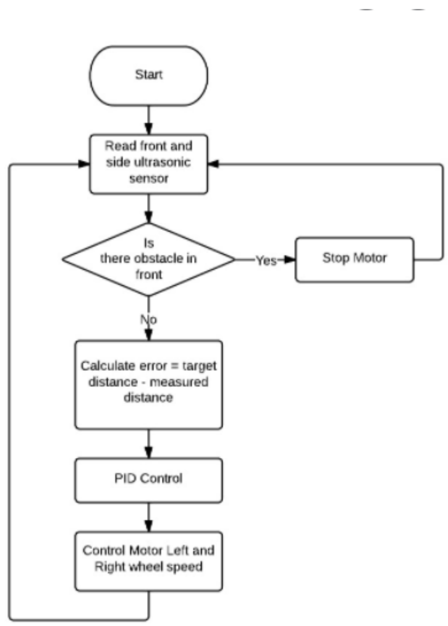

Figure 1: Block diagram of wall following robot

Hardware / Software designing

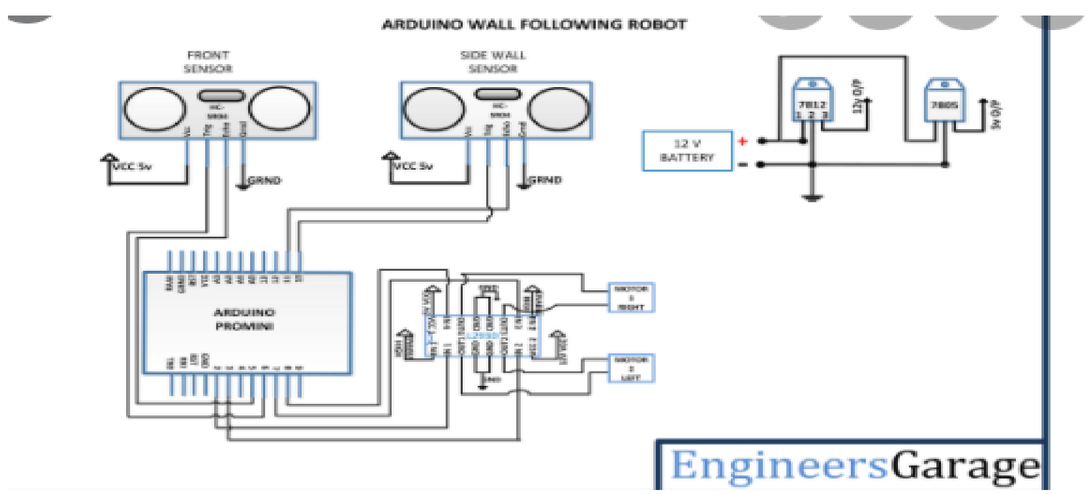

Figure 2: Hardware/software design of wall following robot

Experimental Investigations

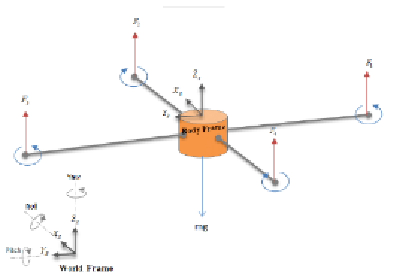

Figure 1. The coordinate systems and the free body diagram

$$R_{EB} = \begin{bmatrix} c\psi c\theta & c\psi s\theta s\phi - s\psi c\phi & c\psi s\theta c\phi + s\psi s\phi \\ s\psi c\theta & s\psi s\theta s\phi + c\psi c\phi & s\psi s\theta c\phi - c\psi s\phi \\ -s\theta & c\theta s\phi & c\theta c\phi \end{bmatrix} \tag{1}$$

where $c\psi$ and $s\psi$ denote $cos(\psi)$ and $sin(\psi)$ respectively, and similarly for other angles.

By obtaining vehicle's vertical forces in the world frame and writing the equations of motion based on the Newton's second law along the X, Y and Z axes, we can write

$$m \begin{bmatrix} \ddot{X} \\ \ddot{Y} \\ \ddot{Z} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -mg \end{bmatrix} + R \begin{bmatrix} 0 \\ 0 \\ \sum F_i \end{bmatrix} \tag{2}$$

where m is the mass of the quadrotor, g is the acceleration due to gravity, F_i is the force from rotor i, given by:

$$F_i = k_f w_i^2 \tag{3}$$

where w_i is the rotational speed of rotor i, and k_f is a constant. In addition, Euler equations are written in order to obtain angular accelerations of the vehicle given by:

$$\begin{aligned} I_x\ddot{\phi} &= l(F_3 - F_1) \\ I_y\ddot{\theta} &= l(F_4 - F_2) \\ I_z\ddot{\psi} &= M_1 - M_2 + M_3 - M_4 \end{aligned} \tag{4}$$

where l is distance of each rotor from the vehicle's center of gravity. I_x, I_y and I_z are moment of inertia along x, y and z directions respectively. M_i, $(i = 1, 2, 3, 4)$ are rotors moment produced by angular velocity of rotors and given by:

$$M_i = K_m \omega_i^2 \tag{5}$$

where ω_i is the angular velocity of i^{th} rotor and K_m is the constant.

Figure 3: Experimental investigation of forces on robot

Flowchart

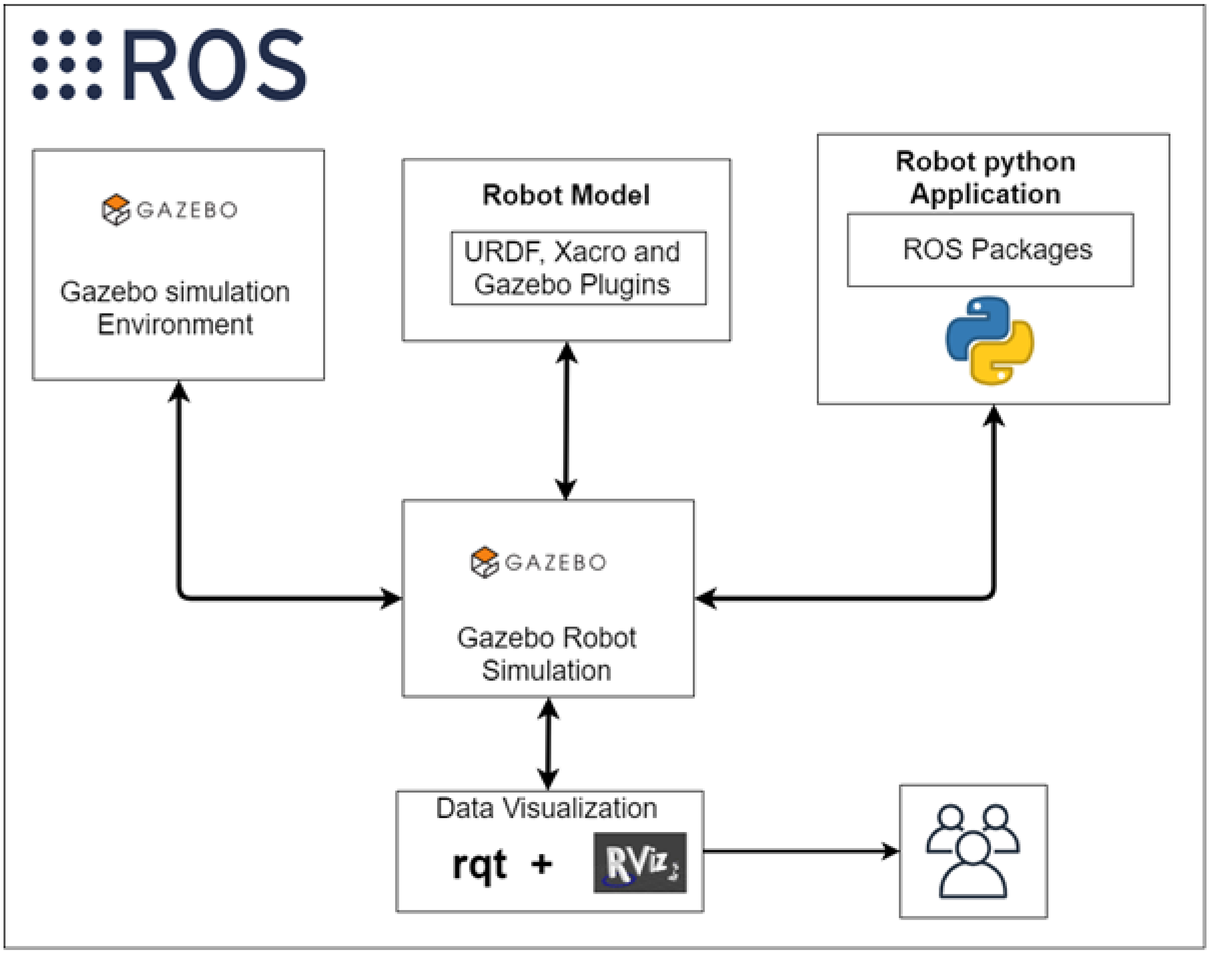

Figure 4: Flow chart of wall following robot

Result

Robot moves along specified path next to wall in Rviz and Gazebo

Robot camera effectively captures robot's movements

Robot laser effectively detects robot's surroundings

Advantages

1) These types of robot movement are usually automatic.
2) The system in the robot is like once install and forget.
3) It's relatively cheap.
4) This type of robot are simple to build.
5) They can also be used for long distance.

Disadvantages

1)Laser may be unable to detect surroundings.
2)Requires the presence of a wall
3)May be complicated to program

Applications

1) They can be used in industries as automated equipment carriers..
2) It can be used for home for floor cleaning etc.
3) In hotels they are being used for the transfer of things from one place to another following a straight path.

4)Useful in military surveilance

Conclusion

Hence, in order to build a robot application that identifies the wall/obstacles, the robot has to follow along the identified wall for a certain distance. The robot should stop whenever it doesn't recognize the wall/obstacle and the robot will collect the wall/obstacle info from the laser distance sensor.

Future Scope

Artificial technology for predicting and detecting crime might seem far-fetched, but it's quite possible for the future we're looking at. Drone footage, for instance, will make that happen soon. In addition, automatic recognition of suspicious activities is already a reality for camera-based security systems.
This technology will change society in a very important way: it will allow law enforcement officials to act quickly whenever a suspicious behavior has been spotted.

The line between classrooms and individual learning settings is already starting to blur. As Kendra Roberts, an educational expert from Essays.ScholarAdvisor, explains, “A single teacher does not have the capacity to meet the needs of personalized learning for every single student in the classroom. Computer-based learning is already changing things in that matter. It’s not replacing the teacher, but it enables students to learn at their own pace.”

Robots will boost the process of personalized learning. NAO, the humanoid robot, is already forming bonds with students from around the world. It comes with important senses of natural interaction, including moving, listening, speaking, and connecting.

Cloud-connected home robots are already becoming part of our lives. We can set up the vacuum cleaner to do the chore for us, and we can schedule a warm home-cooked meal to be ready by the time we’re finished with work. Multi-function robotic cookers are able to fry, steam, bake, slow cook, and perform any other action without our intervention. We just set them up.

These cloud-connected robots are likely to evolve into more advanced version. We expect to see speech comprehension and increased interactions with humans in the upcoming years. These developments may end up changing the entire look and feel of our homes!

Bibliography

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https://www.allerin.com/blog/are-you-aware-of-these-7-challenges-in-robotics

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https://www.futurelearn.com/info/courses/begin-robotics/0/steps/2845

https://brainly.in/question/1620369

https://blog.robotiq.com/10-ways-robotics-could-transform-our-future

Appendix

Source code

```
<?xml version="1.0" ?>

<robot name="robot_1" xmlns:xacro="https://www.ros.org/wiki/xacro" >


<gazebo reference="base_link">

    <material>Gazebo/white</material>

  </gazebo>

  <gazebo reference="left_wheel">

    <material>Gazebo/Red</material>

  </gazebo>

  <gazebo reference="right_wheel">

    <material>Gazebo/Red</material>

  </gazebo>

<gazebo reference="left_f_wheel">

    <material>Gazebo/Orange</material>

  </gazebo>

<gazebo reference="right_f_wheel">

    <material>Gazebo/Orange</material>

  </gazebo>

  <gazebo reference="camera_link">

    <material>Gazebo/Red</material>

</gazebo>

<gazebo reference="hokuyo">

    <material>Gazebo/Green</material>

</gazebo>


  <!-- camera -->
```

```xml
<gazebo reference="camera_link">
  <sensor type="camera" name="camera1">
    <update_rate>30.0</update_rate>
    <camera name="head">
      <horizontal_fov>1.3962634</horizontal_fov>
      <image>
        <width>800</width>
        <height>800</height>
        <format>R8G8B8</format>
      </image>
      <clip>
        <near>0.02</near>
        <far>300</far>
      </clip>
    </camera>
    <plugin name="camera_controller" filename="libgazebo_ros_camera.so">
      <alwaysOn>true</alwaysOn>
      <updateRate>0.0</updateRate>
      <cameraName>m4w_bot/camera1</cameraName>
      <imageTopicName>image_raw</imageTopicName>
      <cameraInfoTopicName>camera_info</cameraInfoTopicName>
      <frameName>camera_link</frameName>
      <hackBaseline>0.07</hackBaseline>
      <distortionK1>0.0</distortionK1>
      <distortionK2>0.0</distortionK2>
      <distortionK3>0.0</distortionK3>
      <distortionT1>0.0</distortionT1>
      <distortionT2>0.0</distortionT2>
    </plugin>
```

```xml
    </sensor>
  </gazebo>

<!-- hokuyo -->
<gazebo reference="hokuyo">
<sensor type="ray" name="head_hokuyo_sensor">
<pose>0 0 0 0 0 0</pose>
<visualize>false</visualize>
<update_rate>40</update_rate>
<ray>
<scan>
<horizontal>
<samples>720</samples>
<resolution>1</resolution>
<min_angle>-1.570796</min_angle>
<max_angle>1.570796</max_angle>
</horizontal>
</scan>

<range>
<min>0.10</min>
<max>30.0</max>
<resolution>0.01</resolution>
</range>
<noise>
<type>gaussian</type>
<!-- Noise parameters based on published spec for Hokuyo laser
achieving "+-30mm" accuracy at range < 10m. A mean of 0.0m and
stddev of 0.01m will put 99.7% of samples within 0.03m of the true
```

```
reading. -->
<mean>0.0</mean>
<stddev>0.01</stddev>
</noise>
</ray>
<plugin name="gazebo_ros_head_hokuyo_controller" filename="libgazebo_ros_laser.so">
<topicName>/mybot/laser/scan</topicName>
<frameName>hokuyo</frameName>
</plugin>
</sensor>
</gazebo>

<gazebo>
  <plugin name="skid_steer_drive_controller" filename="libgazebo_ros_skid_steer_drive.so">
    <updateRate>100.0</updateRate>
    <robotNamespace>/</robotNamespace>
    <leftFrontJoint>left_f_wheel_joint</leftFrontJoint>
    <rightFrontJoint>right_f_wheel_joint</rightFrontJoint>
    <leftRearJoint>left_wheel_joint</leftRearJoint>
    <rightRearJoint>right_wheel_joint</rightRearJoint>
    <wheelSeparation>0.15</wheelSeparation>
    <wheelDiameter>0.07</wheelDiameter>
    <robotBaseFrame>base_link</robotBaseFrame>
    <torque>20</torque>
    <topicName>cmd_vel</topicName>
    <broadcastTF>false</broadcastTF>
  </plugin>
</gazebo>
```

```
  <!-- gazebo>
    <plugin filename="libgazebo_ros_diff_drive.so" name="differential_drive_controller">
      <alwaysOn>true</alwaysOn>
      <updateRate>20</updateRate>
      <leftJoint>left_f_wheel_joint</leftJoint>
      <rightJoint>right_f_wheel_joint</rightJoint>
      <wheelSeparation>0.15</wheelSeparation>
      <wheelDiameter>0.07</wheelDiameter>
      <torque>0.1</torque>
      <commandTopic>cmd_vel</commandTopic>
      <odometryTopic>odom</odometryTopic>
      <odometryFrame>odom</odometryFrame>
      <robotBaseFrame>link_chassis</robotBaseFrame>
    </plugin>
  </gazebo -->

</robot>
<?xml version="1.0"?>
<robot name="m4w_robot" xmlns:xacro="http://www.ros.org/wiki/xacro">
<xacro:include filename="$(find mybot_description)/urdf/materials.xacro" />
<xacro:include filename="$(find mybot_description)/urdf/m4w_robot.gazebo" />

  <xacro:property name="base_width" value="0.16"/>
  <xacro:property name="base_len" value="0.2"/>
  <xacro:property name="wheel_radius" value="0.035"/>
  <xacro:property name="base_wheel_gap" value="0.007"/>
  <xacro:property name="wheel_separation" value="0.15"/>
  <xacro:property name="wheel_joint_offset" value="0.02"/>
```

```
  <xacro:macro name="box_inertia" params="m w h d">

    <inertial>

      <mass value="${m}"/>

      <inertia ixx="${m / 12.0 * (d*d + h*h)}" ixy="0.0" ixz="0.0" iyy="${m / 12.0 * (w*w + h*h)}"
iyz="0.0" izz="${m / 12.0 * (w*w + d*d)}"/>

    </inertial>

  </xacro:macro>


  <link name="base_footprint">

    <xacro:box_inertia m="20" w="0.001" h="0.001" d="0.001"/>

    <visual>

        <origin xyz="0 0 0" rpy="0 0 0" />

        <geometry>

            <box size="0.001 0.001 0.001" />

        </geometry>

                <material name="green"/>

    </visual>

  </link>


  <link name="base_link">

    <xacro:box_inertia m="10" w="${base_len}" h="${base_width}" d="0.02"/>

    <visual>

      <geometry>

        <box size="${base_len} ${base_width} 0.02"/>

      </geometry>

<material name="white"/>

    </visual>

    <collision>
```

```
      <geometry>
        <box size="${base_len} ${base_width} 0.02"/>
      </geometry>

    </collision>
  </link>
   <xacro:macro name="cylinder_inertia" params="m r h">
    <inertial>
      <mass value="${m}"/>
      <inertia ixx="${m*(3*r*r+h*h)/12}" ixy = "0" ixz = "0" iyy="${m*(3*r*r+h*h)/12}" iyz = "0"
izz="${m*r*r/2}"/>
    </inertial>
  </xacro:macro>

  <xacro:macro name="wheel" params="prefix reflect wheel_joint">
    <link name="${prefix}_wheel">
      <visual>
        <origin xyz="0 0 0" rpy="${pi/2} 0 0"/>
        <geometry>
          <cylinder radius="${wheel_radius}" length="0.01"/>
        </geometry>
      </visual>
      <collision>
        <origin xyz="0 0 0" rpy="${pi/2} 0 0"/>
        <geometry>
          <cylinder radius="${wheel_radius}" length="0.01"/>
        </geometry>
      </collision>
      <xacro:cylinder_inertia m="10" r="${wheel_radius}" h="0.005"/>
```

```
    </link>

    <joint name="${prefix}_wheel_joint" type="continuous">
      <axis xyz="0 1 0" rpy="0 0 0" />
      <parent link="base_link"/>
      <child link="${prefix}_wheel"/>
      <origin xyz="${wheel_joint} ${((base_width/2)+base_wheel_gap)*reflect} -0.005" rpy="0 0 0"/>
    </joint>
  </xacro:macro>

  <xacro:wheel prefix="left" reflect="1" wheel_joint="0.08" />
  <xacro:wheel prefix="right" reflect="-1" wheel_joint="0.08"/>
  <xacro:wheel prefix="left_f" reflect="1" wheel_joint="-0.08" />
  <xacro:wheel prefix="right_f" reflect="-1" wheel_joint="-0.08"/>
  <joint name="base_link_joint" type="fixed">
    <origin xyz="0 0 ${wheel_radius + 0.005}" rpy="0 0 0" />
    <parent link="base_footprint"/>
    <child link="base_link" />
  </joint>

<!-- Size of square 'camera' box -->
<xacro:property name="camera_link" value="0.01" />

  <!-- Camera -->
  <link name="camera_link">
    <collision>
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <geometry>
    <box size="${camera_link} ${camera_link} ${camera_link}"/>
```

```
      </geometry>
    </collision>

    <visual>
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <geometry>
    <box size="${camera_link} ${camera_link} ${camera_link}"/>
      </geometry>
      <material name="red"/>
    </visual>

    <inertial>
      <mass value="0.1" />
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <inertia ixx="1e-6" ixy="0" ixz="0" iyy="1e-6" iyz="0" izz="1e-6" />
    </inertial>
  </link>


<joint name="camera_joint" type="fixed">
    <axis xyz="0 1 0" />
    <origin xyz="${base_len/2} 0 0" rpy="0 0 0"/>
    <parent link="base_link"/>
    <child link="camera_link"/>
  </joint>

<!-- Hokuyo Laser -->
<link name="hokuyo">
<collision>
```

```xml
<origin xyz="0 0 0" rpy="0 0 0"/>
<geometry>
<box size="0.03 0.03 0.03"/>
</geometry>
</collision>

<visual>
<origin xyz="0 0 0" rpy="0 0 0"/>
<geometry>
<mesh filename="package://mybot_description/meshes/hokuyo.dae"/>
</geometry>
<material name="green"/>
</visual>

<inertial>
<mass value="1e-5" />
<origin xyz="0 0 0" rpy="0 0 0"/>
<inertia ixx="1e-6" ixy="0" ixz="0" iyy="1e-6" iyz="0" izz="1e-6" />
</inertial>
</link>

<joint name="hokuyo_joint" type="fixed">
<axis xyz="0 1 0" />
<origin xyz="${base_len/2-0.03} 0 0.03" rpy="0 0 0"/>
<parent link="base_link"/>
<child link="hokuyo"/>
</joint>

</robot>
```

```
<?xml version="1.0" ?>
<robot name="m2w_robot" xmlns:xacro="https://www.ros.org/wiki/xacro" >

<material name="black">
    <color rgba="0.0 0.0 0.0 1.0"/>
  </material>
  <material name="blue">
    <color rgba="0.0 0.0 0.8 1.0"/>
  </material>
  <material name="green">
    <color rgba="0.0 0.8 0.0 1.0"/>
  </material>
  <material name="grey">
    <color rgba="0.2 0.2 0.2 1.0"/>
  </material>
  <material name="orange">
    <color rgba="1.0 0.423529411765 0.0392156862745 1.0"/>
  </material>
  <material name="brown">
    <color rgba="0.870588235294 0.811764705882 0.764705882353 1.0"/>
  </material>
  <material name="red">
    <color rgba="0.80078125 0.12890625 0.1328125 1.0"/>
  </material>
  <material name="white">
    <color rgba="1.0 1.0 1.0 1.0"/>
  </material>

</robot>
```

```xml
<?xml version="1.0" encoding="utf-8"?>
<COLLADA xmlns="http://www.collada.org/2005/11/COLLADASchema" version="1.4.1">
<asset>
<contributor>
<author>Blender User</author>
<authoring_tool>Blender 2.64.0 r51232</authoring_tool>
</contributor>
<created>2013-03-22T08:19:53</created>
<modified>2013-03-22T08:19:53</modified>
<unit name="meter" meter="1"/>
<up_axis>Z_UP</up_axis>
</asset>
<library_cameras>
<camera id="Camera-camera" name="Camera">
<optics>
<technique_common>
<perspective>
<xfov sid="xfov">49.13434</xfov>
<aspect_ratio>1.777778</aspect_ratio>
<znear sid="znear">0.1</znear>
<zfar sid="zfar">100</zfar>
</perspective>
</technique_common>
</optics>
</camera>
</library_cameras>
```

```
<library_lights>
<light id="Lamp-light" name="Lamp">
<technique_common>
<point>
<color sid="color">1 1 1</color>
<constant_attenuation>1</constant_attenuation>
<linear_attenuation>0</linear_attenuation>
<quadratic_attenuation>0.00111109</quadratic_attenuation>
</point>
</technique_common>
<extra>
<technique profile="blender">
<adapt_thresh>0.000999987</adapt_thresh>
<area_shape>0</area_shape>
<area_size>1</area_size>
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<area_sizez>1</area_sizez>
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<atm_extinction_factor>1</atm_extinction_factor>
<atm_turbidity>2</atm_turbidity>
<att1>0</att1>
<att2>1</att2>
<backscattered_light>1</backscattered_light>
<bias>1</bias>
<blue>1</blue>
<buffers>1</buffers>
<bufflag>0</bufflag>
<bufsize>2880</bufsize>
<buftype>2</buftype>
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<clipend>30.002</clipend>

<clipsta>1.000799</clipsta>

<compressthresh>0.04999995</compressthresh>

<dist sid="blender_dist">29.99998</dist>

<energy sid="blender_energy">1</energy>

<falloff_type>2</falloff_type>

<filtertype>0</filtertype>

<flag>0</flag>

<gamma sid="blender_gamma">1</gamma>

<green>1</green>

<halo_intensity sid="blnder_halo_intensity">1</halo_intensity>

<horizon_brightness>1</horizon_brightness>

<mode>8192</mode>

<ray_samp>1</ray_samp>

<ray_samp_method>1</ray_samp_method>

<ray_samp_type>0</ray_samp_type>

<ray_sampy>1</ray_sampy>

<ray_sampz>1</ray_sampz>

<red>1</red>

<samp>3</samp>

<shadhalostep>0</shadhalostep>

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<shadow_g sid="blender_shadow_g">0</shadow_g>

<shadow_r sid="blender_shadow_r">0</shadow_r>

<shadspotsize>45</shadspotsize>

<sky_colorspace>0</sky_colorspace>

<sky_exposure>1</sky_exposure>

<skyblendfac>1</skyblendfac>

<skyblendtype>1</skyblendtype>

<soft>3</soft>

<spotblend>0.15</spotblend>

<spotsize>75</spotsize>

<spread>1</spread>

<sun_brightness>1</sun_brightness>

<sun_effect_type>0</sun_effect_type>

<sun_intensity>1</sun_intensity>

<sun_size>1</sun_size>

<type>0</type>

</technique>

</extra>

</light>

</library_lights>

<library_images/>

<library_effects>

<effect id="black-effect">

<profile_COMMON>

<technique sid="common">

<phong>

<emission>

<color sid="emission">0 0 0 1</color>

</emission>

<ambient>

<color sid="ambient">0 0 0 1</color>

</ambient>

<diffuse>

<color sid="diffuse">0.020312 0.020312 0.020312 1</color>

</diffuse>

<specular>

```
<color sid="specular">0.25 0.25 0.25 1</color>
</specular>
<shininess>
<float sid="shininess">12</float>
</shininess>
<index_of_refraction>
<float sid="index_of_refraction">1</float>
</index_of_refraction>
</phong>
</technique>
<extra>
<technique profile="GOOGLEEARTH">
<double_sided>1</double_sided>
</technique>
</extra>
</profile_COMMON>
<extra><technique profile="MAX3D"><double_sided>1</double_sided></technique></extra>
</effect>
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</emission>
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<color sid="ambient">0 0 0 1</color>
</ambient>
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440 884 433 884 438 885 431 885 425 885 438 886 425 886 427 886 438 887 427 887 454 887 454 888 427 888 429 888 454 889 429 889 450 889 454 890 450 890 467 890 456 891 455 891 439 891 439 892 455 892 441 892 455 893 456 893 466 893 455 894 466 894 449 894 455 895 449 895 428 895 455 896 428 896 441 896 441 897 428 897 426 897 481 898 483 898 499 898 514 899 512 899 499 899 499 900 512 900 497 900 499 901 497 901 481 901 512 902 514 902 520 902 512 903 520 903 528 903 512 904 528 904 526 904 512 905 526 905 497 905 497 906 526 906 524 906 497 907 503 907 481 907 525 908 498 908 504 908 504 909 498 909 482 909 529 910 521 910 527 910 527 911 521 911 513 911 498 912 525 912 527 912 498 913 527 913 513 913 498 914 513 914 515 914 515 915 513 915 523 915 523 916 513 916 521 916 498 917 500 917 482 917 482 918 500 918 484 918 462 945 489 945 487 945 462 946 487 946 472 946 472 1062 463 1062 462 1062 463 1064 472 1064 464 1064 645 1104 450 1104 504 1104 504 1105 482 1105 645 1105 482 1106 467 1106 645 1106 467 1107 450 1107 645 1107 646 1108 452 1108 465 1108 489 1109 462 1109 646 1109 646 1110 506 1110 505 1110 646 1111 465 1111 474 1111 463 1112 464 1112 646 1112 447 1113 448 1113 646 1113 646 1114 492 1114 502 1114 646 1115 490 1115 492 1115 646 1116 502 1116 507 1116 646 1117 448 1117 452 1117 646 1118 507 1118 506 1118 446 1119 447 1119 646 1119 462 1120 463 1120 646 1120 501 1121 491 1121 646 1121 505 1122 501 1122 646 1122 451 1123 446 1123 646 1123 646 1124 480 1124 490 1124 646 1125 474 1125 480 1125 491 1126 489 1126 646 1126 464 1127 451 1127 646 1127</p>

</polylist>

</mesh>

<extra><technique profile="MAYA"><double_sided>1</double_sided></technique></extra>

</geometry>

</library_geometries>

<library_visual_scenes>

<visual_scene id="Scene" name="Scene">

<node id="Camera" name="Camera" type="NODE">

<translate sid="location">7.481132 -6.50764 5.343665</translate>

<rotate sid="rotationZ">0 0 1 46.69194</rotate>

<rotate sid="rotationY">0 1 0 0.619768</rotate>

<rotate sid="rotationX">1 0 0 63.5593</rotate>

<scale sid="scale">1 1 1</scale>

<instance_camera url="#Camera-camera"/>

</node>

<node id="Lamp" name="Lamp" type="NODE">

<translate sid="location">4.076245 1.005454 5.903862</translate>

```xml
<rotate sid="rotationZ">0 0 1 106.9363</rotate>
<rotate sid="rotationY">0 1 0 3.163707</rotate>
<rotate sid="rotationX">1 0 0 37.26105</rotate>
<scale sid="scale">1 1 1</scale>
<instance_light url="#Lamp-light"/>
</node>
<node id="Mesh_001" name="Mesh_001" type="NODE">
<translate sid="location">0 0 0</translate>
<rotate sid="rotationZ">0 0 1 0</rotate>
<rotate sid="rotationY">0 1 0 0</rotate>
<rotate sid="rotationX">1 0 0 90.00001</rotate>
<scale sid="scale">1 1 1</scale>
<instance_geometry url="#Mesh-mesh">
<bind_material>
<technique_common>
<instance_material symbol="black-material" target="#black-material"/>
<instance_material symbol="white_001-material" target="#white_001-material"/>
</technique_common>
</bind_material>
</instance_geometry>
</node>
</visual_scene>
</library_visual_scenes>
<scene>
<instance_visual_scene url="#Scene"/>
</scene>
</COLLADA>
<?xml version="1.0"?>
<launch>
```

```
  <param name="robot_description" command="$(find xacro)/xacro '$(find mybot_description)/urdf/m4w_robot.xacro'"/>

  <!-- send fake joint values -->
  <node name="joint_state_publisher" pkg="joint_state_publisher" type="joint_state_publisher">
    <param name="use_gui" value="False"/>
  </node>

  <!-- Combine joint values -->
  <node name="robot_state_publisher" pkg="robot_state_publisher" type="robot_state_publisher"/>

  <!-- Show in Rviz   -->
  <node name="rviz" pkg="rviz" type="rviz" />

</launch>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<launch>
    <param name="robot_description" command="$(find xacro)/xacro '$(find mybot_description)/urdf/m4w_robot.xacro'" />

    <arg name="x" default="0"/>
    <arg name="y" default="0"/>
    <arg name="z" default="0"/>

    <node name="mybot_spawn" pkg="gazebo_ros" type="spawn_model" output="screen"
          args="-urdf -param robot_description -model m2wr -x $(arg x) -y $(arg y) -z $(arg z)" />
</launch>
```

```xml
<?xml version="1.0" encoding="UTF-8"?>
<launch>

  <arg name="world" default="empty"/>
  <arg name="paused" default="false"/>
  <arg name="use_sim_time" default="true"/>
  <arg name="gui" default="true"/>
  <arg name="headless" default="false"/>
  <arg name="debug" default="false"/>

  <include file="$(find gazebo_ros)/launch/empty_world.launch">
    <arg name="world_name" value="$(find mybot_gazebo)/worlds/wall.world"/>
    <arg name="paused" value="$(arg paused)"/>
    <arg name="use_sim_time" value="$(arg use_sim_time)"/>
    <arg name="gui" value="$(arg gui)"/>
    <arg name="headless" value="$(arg headless)"/>
    <arg name="debug" value="$(arg debug)"/>
  </include>
  <param name="robot_description" command="$(find xacro)/xacro '$(find
mybot_description)/urdf/m4w_robot.xacro'"/>
  <!-- send fake joint values -->
  <node name="joint_state_publisher" pkg="joint_state_publisher" type="joint_state_publisher">
    <param name="use_gui" value="False"/>
  </node>

  <!-- Combine joint values -->
  <node name="robot_state_publisher" pkg="robot_state_publisher" type="robot_state_publisher"/>

  <!-- Show in Rviz   -->
```

```
  <node name="rviz" pkg="rviz" type="rviz" />


  <node name="mybot_spawn" pkg="gazebo_ros" type="spawn_model" output="screen" args="-urdf
-param robot_description -model mybot" />

  </launch>

<?xml version="1.0" ?>

<sdf version="1.4">

  <world name="default">

    <include>

      <uri>model://ground_plane</uri>

    </include>


    <!-- Global light source -->

    <include>

      <uri>model://sun</uri>

    </include>


    <!-- Focus camera on tall pendulum -->

    <gui fullscreen='0'>

      <camera name='user_camera'>

        <pose>4.927360 -4.376610 3.740080 0.000000 0.275643 2.356190</pose>

        <view_controller>orbit</view_controller>

      </camera>

    </gui>


<model name="left">

    <link name="link">

      <pose>0 -9.5 0 0 0 0</pose>

      <inertial>
```

```
  <mass>50</mass>
  <inertia>
    <ixx>8.3333</ixx>
    <ixy>0</ixy>
    <ixz>0</ixz>
    <iyy>1671</iyy>
    <iyz>0</iyz>
    <izz>1671</izz>
  </inertia>
</inertial>

<collision name="collision">
  <geometry>
    <box>
      <size>20 1 1</size>
    </box>
  </geometry>
  <max_contacts>10</max_contacts>
    <surface>
      <contact>
        <ode/>
      </contact>
      <bounce/>
      <friction>
        <torsional>
          <ode/>
        </torsional>
        <ode/>
      </friction>
```

```
          </surface>
        </collision>

        <visual name="visual">
          <geometry>
            <box>
              <size>20 1 1</size>
            </box>
          </geometry>
          <material>
            <script>
              <uri>file://media/materials/scripts/gazebo.material</uri>
              <name>Gazebo/Wood</name>
            </script>
          </material>
        </visual>

      </link>
    </model>

  <model name="right">
      <link name="link">
        <pose>0 9.5 0 0 0 0</pose>
        <inertial>
          <mass>50</mass>
          <inertia>
            <ixx>8.3333</ixx>
            <ixy>0</ixy>
            <ixz>0</ixz>
```

```
    <iyy>1671</iyy>
    <iyz>0</iyz>
    <izz>1671</izz>
  </inertia>
</inertial>

<collision name="collision">
  <geometry>
    <box>
      <size>20 1 1</size>
    </box>
  </geometry>
  <max_contacts>10</max_contacts>
    <surface>
      <contact>
        <ode/>
      </contact>
      <bounce/>
      <friction>
        <torsional>
          <ode/>
        </torsional>
        <ode/>
      </friction>
    </surface>
</collision>

<visual name="visual">
  <geometry>
```

```
          <box>
            <size>20 1 1</size>
          </box>
        </geometry>
        <material>
          <script>
            <uri>file://media/materials/scripts/gazebo.material</uri>
            <name>Gazebo/Wood</name>
          </script>
        </material>
      </visual>

    </link>
  </model>
<model name="east">
    <link name="link">
      <pose>-9.5 0 0 0 0 0</pose>
      <inertial>
        <mass>50</mass>
        <inertia>
          <ixx>1354.2</ixx>
          <ixy>0</ixy>
          <ixz>0</ixz>
          <iyy>8.3333</iyy>
          <iyz>0</iyz>
          <izz>1354.2</izz>
        </inertia>
      </inertial>
```

```
<collision name="collision">
  <geometry>
    <box>
      <size>1 18 1</size>
    </box>
  </geometry>
  <max_contacts>10</max_contacts>
    <surface>
      <contact>
        <ode/>
      </contact>
      <bounce/>
      <friction>
        <torsional>
          <ode/>
        </torsional>
        <ode/>
      </friction>
    </surface>
</collision>

<visual name="visual">
  <geometry>
    <box>
      <size>1 18 1</size>
    </box>
  </geometry>
  <material>
    <script>
```

```
            <uri>file://media/materials/scripts/gazebo.material</uri>
            <name>Gazebo/Wood</name>
          </script>
        </material>
      </visual>

    </link>
  </model>
<model name="west">
    <link name="link">
      <pose>9.5 0 0 0 0 0</pose>
      <inertial>
        <mass>50</mass>
        <inertia>
          <ixx>1354.2</ixx>
          <ixy>0</ixy>
          <ixz>0</ixz>
          <iyy>8.333</iyy>
          <iyz>0</iyz>
          <izz>1354.2</izz>
        </inertia>
      </inertial>

      <collision name="collision">
        <geometry>
          <box>
            <size>1 18 1</size>
          </box>
        </geometry>
```

```
  <max_contacts>10</max_contacts>
    <surface>
      <contact>
        <ode/>
      </contact>
      <bounce/>
      <friction>
        <torsional>
          <ode/>
        </torsional>
        <ode/>
      </friction>
    </surface>
</collision>

<visual name="visual">
  <geometry>
    <box>
      <size>1 18 1</size>
    </box>
  </geometry>
  <material>
    <script>
      <uri>file://media/materials/scripts/gazebo.material</uri>
      <name>Gazebo/Wood</name>
    </script>
  </material>
</visual>
```

```
    </link>
  </model>

  </world>
</sdf>
#!/usr/bin/env python2

import rospy  #python client library for ROS
from sensor_msgs.msg import LaserScan #package for Laser sensor integrated with robot
from geometry_msgs.msg import Twist    #package defines common geometric primitives such as Points,
vectors and poses.
from nav_msgs.msg import Odometry   #package is used ti interact with navigation stack
from tf import transformations      #tf is ued to display coordinate frames of a robot

import math   #package for using mathematical functions

pub_ = None
regions_ = {
        'right': 0,
        'fright': 0,
        'front': 0,
        'fleft': 0,
        'left': 0,
}
state_ = 0
state_dict_ = {
    0: 'find the wall',
    1: 'turn left',
    2: 'follow the wall',
```

```
}

def clbk_laser(msg):  #to check in which region the obstacle is present
    global regions_
    regions_ = {
        'right':  min(min(msg.ranges[0:143]), 10),
        'fright': min(min(msg.ranges[144:287]), 10),
        'front':  min(min(msg.ranges[288:431]), 10),
        'fleft':  min(min(msg.ranges[432:575]), 10),
        'left':   min(min(msg.ranges[576:713]), 10),
    }

    take_action()

def change_state(state):  #to print the state of the robot in console
    global state_, state_dict_
    if state is not state_:
        print('Wall follower - [%s] - %s' % (state, state_dict_[state]))
        state_ = state

def take_action():  # to take the required direction to move forward
    global regions_
    regions = regions_
    msg = Twist()
    linear_x = 0
    angular_z = 0
    state_description = ''
    d = 0.5
    if regions['front'] > d and regions['fleft'] > d and regions['fright'] > d:
```

```
        state_description = 'case 1 - nothing'
        change_state(0)
    elif regions['front'] < d and regions['fleft'] > d and regions['fright'] > d:
        state_description = 'case 2 - front'
        change_state(1)
    elif regions['front'] > d and regions['fleft'] > d and regions['fright'] < d:
        state_description = 'case 3 - fright'
        change_state(2)
    elif regions['front'] > d and regions['fleft'] < d and regions['fright'] > d:
        state_description = 'case 4 - fleft'
        change_state(0)
    elif regions['front'] < d and regions['fleft'] > d and regions['fright'] < d:
        state_description = 'case 5 - front and fright'
        change_state(1)
    elif regions['front'] < d and regions['fleft'] < d and regions['fright'] > d:
        state_description = 'case 6 - front and fleft'
        change_state(1)
    elif regions['front'] < d and regions['fleft'] < d and regions['fright'] < d:
        state_description = 'case 7 - front and fleft and fright'
        change_state(1)
    elif regions['front'] > d and regions['fleft'] < d and regions['fright'] < d:
        state_description = 'case 8 - fleft and fright'
        change_state(0)
    else:
        state_description = 'unknown case'
        rospy.loginfo(regions)

def find_wall(): # funstion for finding the wall
    msg = Twist()
```

```
    msg.linear.x = 1.0
    msg.angular.z = 0.0
    rospy.loginfo("Finding Wall")
    return msg

def turn_left(): # function to turn left
    msg = Twist()
    msg.angular.z = 0.3
    rospy.loginfo("Turning Left")
    return msg

def follow_the_wall(): # function to follow the wall
    global regions_

    msg = Twist()
    msg.linear.x = 0.5
    rospy.loginfo('Following the Wall')
    return msg

def main(): # main function
    global pub_

    rospy.init_node('reading_laser')

    pub_ = rospy.Publisher('/cmd_vel', Twist, queue_size=1)

    sub = rospy.Subscriber('/mybot/laser/scan', LaserScan, clbk_laser)

    rate = rospy.Rate(20)
```

```
    while not rospy.is_shutdown():
        msg = Twist()
        if state_ == 0:
            msg = find_wall()
        elif state_ == 1:
            msg = turn_left()
        elif state_ == 2:
            msg = follow_the_wall()
            pass
        else:
            rospy.logerr('Unknown state!')

        pub_.publish(msg)

        rate.sleep()

if __name__ == '__main__':
    main()
```

Source Output

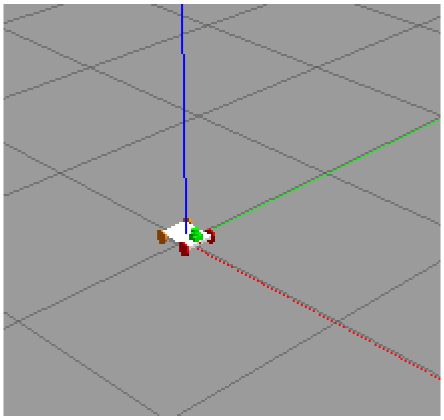

Figure 5: Gazebo output

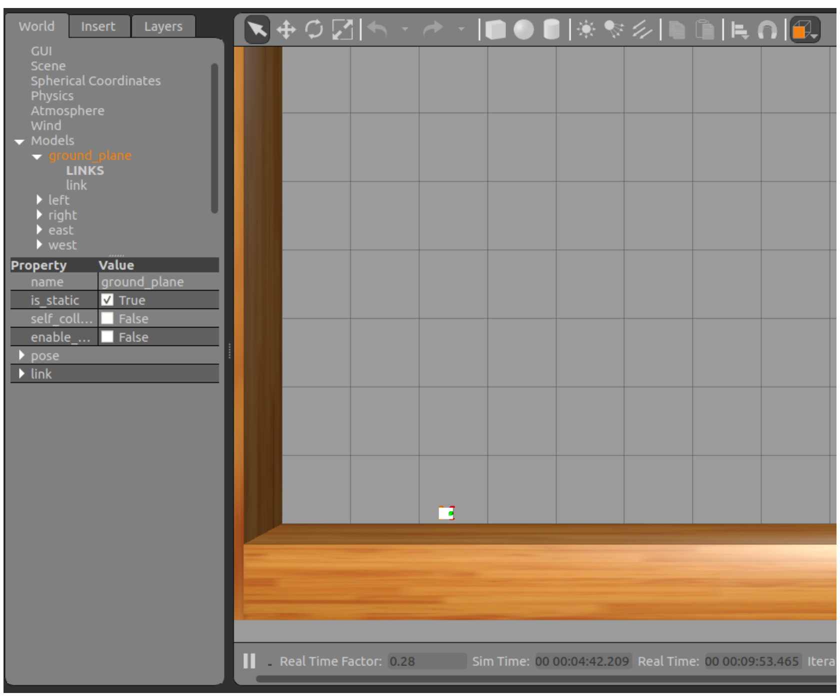

Figure 6: Gazebo wall following robot

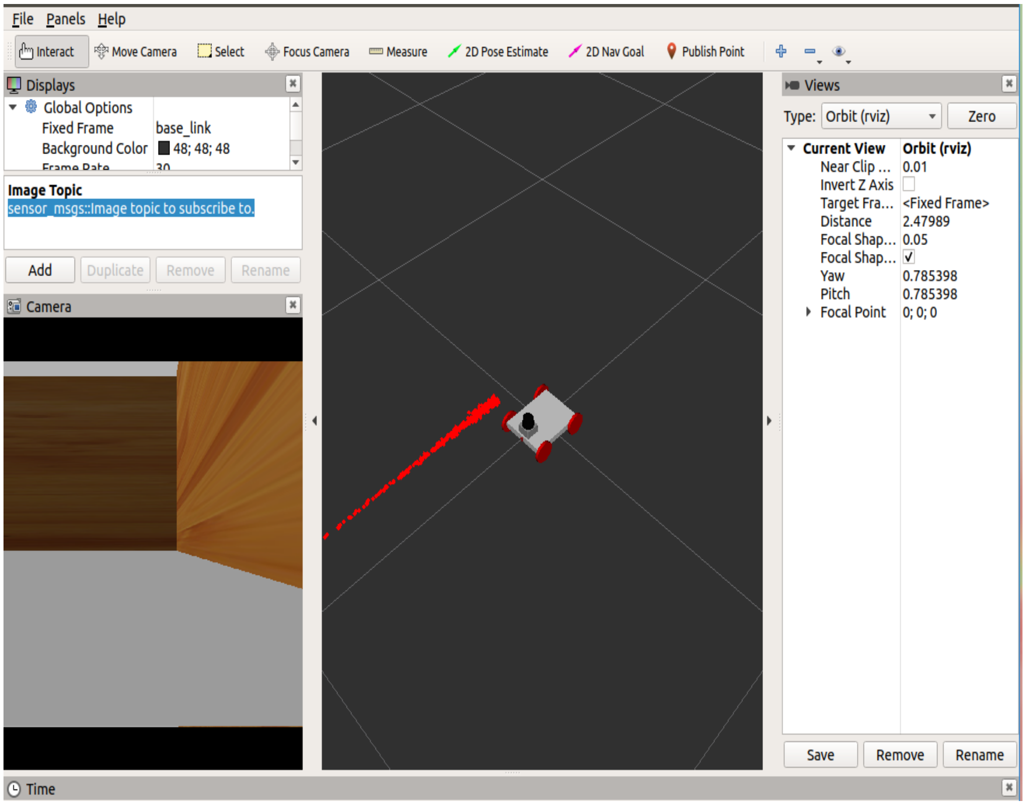

Figure 7: Gazebo Rviz simulation

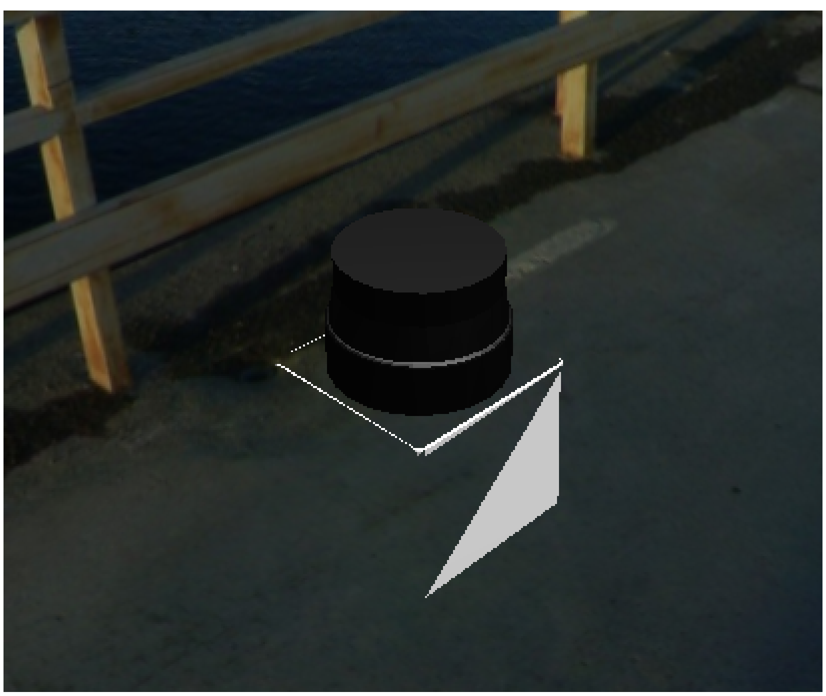

Figure 8: Hokuyo dae