ROS Lab 6 Classwork

Vipul Dinesh, 220929024, MTE-A-09

1. Get the following required packages

- `sudo apt install libopencv-dev python3-opencv`

2. Create perception package

- `cd ~/ros2_ws/src`
- `ros2 pkg create --build-type ament_python perception --dependencies rclpy std-msgs`

3. Make urdf and launch sub-folders in `perception` package folder

- `mkdir ~/ros2_ws/src/perception/urdf`
- `mkdir ~/ros2_ws/src/perception/launch`

4. Create a urdf file called `car.urdf` in the urdf directory just created and fill content as follows

`car.urdf`

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


<robot name = "car">


   <link name="base">

       <visual>

       <geometry>

           <box size="0.75 0.4 0.1"/>

       </geometry>

       <material name="pink">

           <color rgba="1 0 1 1" />

       </material>

       </visual>


       <inertial>
```

```
                <mass value="1" />
                <inertia ixx="0.01" ixy="0.0" ixz="0" iyy="0.01"
iyz="0" izz="0.01" />
            </inertial>

            <collision>
            <geometry>
                <box size="0.75 0.4 0.1"/>
            </geometry>
            </collision>

        </link>

        <link name="wheel_right_link">
            <inertial>
                    <mass value="2" />
                    <inertia ixx="0.01" ixy="0.0" ixz="0"
                    iyy="0.01" iyz="0" izz="0.01" />
            </inertial>

            <visual>
                <geometry>
                  <cylinder radius="0.15" length="0.1"/>
                </geometry>
```

```
            <material name="blue">
            <color rgba="0 0 1 1"/>
            </material>
        </visual>

        <collision>
            <geometry>
              <cylinder radius="0.15" length="0.1"/>
            </geometry>
          <contact_coefficients mu="1" kp="1e+13" kd="1.0"/>
        </collision>
    </link>

    <joint name="wheel_right_joint" type="continuous">
        <origin xyz="0.2 0.25 0.0" rpy="1.57 0.0 0.0"/>
        <parent link="base"/>
        <child link="wheel_right_link"/>
        <axis xyz="0.0 0.0 1.0"/>
    </joint>



    <link name="wheel_left_link">
```

```
        <inertial>
            <mass value="2" />
            <inertia ixx="0.01" ixy="0.0" ixz="0"
                iyy="0.01" iyz="0" izz="0.01" />
        </inertial>

        <visual>
          <geometry>
              <cylinder radius="0.15" length="0.1"/>
          </geometry>
          <material name="blue">
            <color rgba="0 0 1 1"/>
          </material>
        </visual>

        <collision>
          <geometry>
              <cylinder radius="0.15" length="0.1"/>
          </geometry>
          <contact_coefficients mu="1" kp="1e+13" kd="1.0"/>
        </collision>
    </link>
```

```
    <joint name="wheel_left_joint" type="continuous">
        <origin xyz="0.2 -0.25 0.0" rpy="1.57 0.0 0.0"/>
        <parent link="base"/>
        <child link="wheel_left_link"/>
        <axis xyz="0.0 0.0 1.0"/>
    </joint>




    <link name="caster">
        <inertial>
                <mass value="1" />
                <inertia ixx="0.01" ixy="0.0" ixz="0"
                iyy="0.01" iyz="0" izz="0.01" />
        </inertial>


        <visual>
          <geometry>
            <sphere radius=".08" />
          </geometry>
          <material name="white" />
        </visual>
```

```
    <collision>
      <origin/>
      <geometry>
        <sphere radius=".08" />
      </geometry>
    </collision>
  </link>

  <joint name="caster_joint" type="continuous">
    <origin xyz="-0.3 0.0 -0.07" rpy="0.0 0.0 0.0"/>
    <axis xyz="0 0 1" />
    <parent link="base"/>
    <child link="caster"/>
  </joint>

  <link name="camera">
    <inertial>
      <mass value="0.5" />
      <inertia ixx="0.01" ixy="0.0" ixz="0"
      iyy="0.01" iyz="0" izz="0.01" />
    </inertial>
```

```
        <visual>
            <geometry>
                <box size="0.1 0.1 0.1"/>
            </geometry>
            <material name="red">
                <color rgba="1 0 0 1"/>
            </material>
        </visual>

        <collision>
            <geometry>
                <box size="0.1 0.1 0.1"/>
            </geometry>
        </collision>
    </link>



    <joint name="camera_joint" type="fixed">
        <origin xyz="-0.32 0 0.1" rpy="0 0.0 3.14"/>
        <parent link="base"/>
        <child link="camera"/>
        <axis xyz="0.0 0.0 1.0"/>
    </joint>
```

```
        <!--
http://wiki.ros.org/simulator_gazebo/Tutorials/ListOfMaterials-->
        <gazebo reference="base">
            <material>Gazebo/WhiteGlow</material>
        </gazebo>
        <gazebo reference="wheel_left_link">
            <material>Gazebo/SkyBlue</material>
        </gazebo>
        <gazebo reference="wheel_right_link">
            <material>Gazebo/SkyBlue </material>
        </gazebo>
        <gazebo reference="caster">
            <material>Gazebo/Grey</material>
        </gazebo>
        <gazebo reference="camera">
            <material>Gazebo/Blue</material>
        </gazebo>
```

```
        <!-- differential robot-->
        <gazebo>
            <plugin filename="libgazebo_ros_diff_drive.so"
name="gazebo_base_controller">
              <odometry_frame>odom</odometry_frame>
              <commandTopic>cmd_vel</commandTopic>
              <publish_odom>true</publish_odom>
              <publish_odom_tf>true</publish_odom_tf>
              <update_rate>15.0</update_rate>

              <left_joint>wheel_left_joint</left_joint>
              <right_joint>wheel_right_joint</right_joint>

              <wheel_separation>0.5</wheel_separation>
              <wheel_diameter>0.3</wheel_diameter>
              <max_wheel_acceleration>0.7</max_wheel_acceleration>
              <max_wheel_torque>8</max_wheel_torque>
              <robotBaseFrame>base</robotBaseFrame>
            </plugin>
        </gazebo>

        <!-- camera plugin-->
```

```
        <gazebo reference="camera">
            <sensor type="camera" name="camera1">
              <visualize>true</visualize>
              <update_rate>30.0</update_rate>
              <camera name="head">
                <horizontal_fov>1.3962634</horizontal_fov>
                <image>
                  <width>512</width>
                  <height>512</height>
                  <format>R8G8B8</format>
                </image>
                <clip>
                  <near>0.02</near>
                  <far>500</far>
                </clip>
              </camera>
              <plugin name="camera_controller"
filename="libgazebo_ros_camera.so">
                <alwaysOn>true</alwaysOn>
                <updateRate>0.0</updateRate>
                <cameraName>/camera</cameraName>
                <imageTopicName>image_raw</imageTopicName>
```

```
<cameraInfoTopicName>camera_info</cameraInfoTopicName>

                <frameName>camera_link</frameName>

                <hackBaseline>0.07</hackBaseline>

              </plugin>

            </sensor>

            <material>Gazebo/Blue</material>

          </gazebo>

      </robot>/
```

5. In the launch folder, create launch files for gazebo and rviz such that they use the `car.urdf` file. Name them as `gazebo.launch.py` and `rviz.launch.py` respectively and fill the content as follows

`gazebo.launch.py`

```
      import os
      from ament_index_python.packages import
get_package_share_directory
      from launch import LaunchDescription
      from launch.actions import DeclareLaunchArgument,
ExecuteProcess
      from launch.substitutions import LaunchConfiguration
      from launch_ros.actions import Node
      from launch.launch_description_sources import
PythonLaunchDescriptionSource

      def generate_launch_description():
         urdf = '/home/vipul/ros2_ws/src/perception/urdf/car.urdf'
         return LaunchDescription([
             Node(
                 package='robot_state_publisher',
                 executable='robot_state_publisher',
                 name='robot_state_publisher',
                 output='screen',
                 arguments=[urdf]),
             Node(
                 package='joint_state_publisher',
                 executable='joint_state_publisher',
```

```
                name='joint_state_publisher',
                arguments=[urdf]),
        # Gazebo related stuff required to launch the robot in
simulation
            ExecuteProcess(
                cmd=['gazebo', '--verbose', '-s',
'libgazebo_ros_factory.so'],
                output='screen'),
            Node(
                package='gazebo_ros',
                executable='spawn_entity.py',
                name='urdf_spawner',
                output='screen',
                arguments=["-topic", "/robot_description", "-
entity", "perception"])
        ])
```

rviz.launch.py

```
      import os
      from ament_index_python.packages import
get_package_share_directory

      from launch import LaunchDescription
      from launch_ros.actions import Node

      def generate_launch_description():
         package_dir='/home/vipul/ros2_ws/src/perception/urdf'
         urdf = os.path.join(package_dir,'car.urdf')
         # rviz_config_file=os.path.join(package_dir,'config.rviz')
         return LaunchDescription([
            Node(
                package='robot_state_publisher',
                executable='robot_state_publisher',
                name='robot_state_publisher',
                output='screen',
                arguments=[urdf]),
            Node(
                package='joint_state_publisher_gui',
                executable='joint_state_publisher_gui',
                name='joint_state_publisher_gui',
                arguments=[urdf]),
            Node(
                package='rviz2',
                executable='rviz2',
                name='rviz2',
```

```
                # arguments=['-d',rviz_config_file],
                output='screen'),
        ])
```

6. Create nodes called `capture_image.py`, `extract_road.py` and `line_follower.py` in the directory `~/ros2_ws/src/perception/perception`

`capture_image.py`

```
    import rclpy
    import cv2
    from rclpy.node import Node
    from cv_bridge import CvBridge
    from sensor_msgs.msg import Image
    class Capture(Node):
        def __init__(self):
            super().__init__('video_subscriber')

self.subscriber=self.create_subscription(Image,'/camera1/image_raw',s
elf.process_data,10)
            self.out =
cv2.VideoWriter('/home/vipul/ros2_ws/src/perception/resource/output.a
vi',cv2.VideoWriter_fourcc('M','J','P','G'), 10, (512,512))
            self.bridge = CvBridge()
        def process_data(self, data):
            frame = self.bridge.imgmsg_to_cv2(data)
            self.out.write(frame)
            self.img =
cv2.imwrite('/home/vipul/ros2_ws/src/perception/resource/shot.png',
frame)
            cv2.imshow("output", frame)
            cv2.waitKey()
            cv2.destroyAllWindows()

    def main(args=None):
        rclpy.init(args=args)
        node = Capture()
        rclpy.spin(node)
        rclpy.shutdown()

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

`extract_road.py`

```
    import cv2
    import numpy
```

```
      image =
cv2.imread('/home/vipul/ros2_ws/src/perception/resource/shot.png')

      def mouse(event,x,y,flags,param):
         if event==cv2.EVENT_LBUTTONDOWN:
             h=image[y,x,0]
             s=image[y,x,1]
             v=image[y,x,2]
             print("H:",h)
             print("S:",s)
             print("V:",v)

      cv2.namedWindow('mouse')
      cv2.setMouseCallback('mouse',mouse)

      cv2.imshow("original image", image)
      cv2.imshow("mouse", image)
      cv2.waitKey(0)
      cv2.destroyAllWindows()

      light_line = numpy.array([120,120,0])
      dark_line = numpy.array([150,150,10])
      mask = cv2.inRange(image, light_line,dark_line)
      cv2.imshow('mask', mask)
      cv2.waitKey(0)
      cv2.destroyAllWindows()

      canny= cv2.Canny(mask,30,5)
      cv2.imshow('edge', canny)
      cv2.waitKey(0)
      cv2.destroyAllWindows()
      print(canny.shape)

      r1=200;c1=0
      img = canny[r1:r1+200,c1:c1+512]
      cv2.imshow('crop', img)
      cv2.waitKey(0)
      cv2.destroyAllWindows()

      edge=[]
      row =150

      for i in range (512):
         if(img[row,i]==255):
```

```
                edge.append(i)
        print(edge)

        if(len(edge)==4):
            left_edge=edge[0]
            right_edge=edge[2]
            print(edge)
        if(len(edge)==3):
            if(edge[1]-edge[0] > 5):
                left_edge=edge[0]
                right_edge=edge[1]
            else:
                left_edge=edge[0]
                right_edge=edge[2]

        road_width=(right_edge-left_edge)
        frame_mid = left_edge + (road_width/2)
        mid_point = 512/2
        img[row,int(mid_point)]=255
        print(mid_point)
        error=mid_point-frame_mid

        if(error < 0):
            action="Go Right"
        else :
            action="Go Left"

        print("error", error)
        img[row,int(frame_mid)]=255
        print("mid point of the frame", frame_mid)

        f_image = cv2.putText(img, action, (50,50),
cv2.FONT_HERSHEY_SIMPLEX, 1,
        (255,0,0), 1, cv2.LINE_AA)
        cv2.imshow('final image',f_image)
        cv2.waitKey(0)
        cv2.destroyAllWindows()
```

extract_road.py

```
        import numpy
        import rclpy
        from rclpy.node import Node
        from cv_bridge import CvBridge
        from sensor_msgs.msg import Image
        from geometry_msgs.msg import Twist
```

```
      import cv2

      class LineFollower(Node):
         def __init__(self):
             super().__init__('line_follower')
             self.bridge = CvBridge()
             self.subscriber =
self.create_subscription(Image,'/camera1/image_raw',self.process_
data, 10)
             self.publisher = self.create_publisher(Twist,
'/cmd_vel', 40)
             timer_period = 0.2
             self.timer = self.create_timer(timer_period,
self.send_cmd_vel)
             self.velocity=Twist()
             self.empty = False
             self.error = 0
             self.action=""
             self.get_logger().info("Node Started!")

         def send_cmd_vel(self):
             if(self.empty):
                 self.velocity.linear.x=0.0
                 self.velocity.angular.z= 0.0
                 self.action="Stop"
             else:
                 if(self.error > 0):
                     self.velocity.linear.x=0.1
                     self.velocity.angular.z=0.1
                     self.action="Go Left"
                 elif(self.error < 0):
                     self.velocity.linear.x=0.1
                     self.velocity.angular.z=-0.1
                     self.action="Go Right"
                 elif(self.error==0):
                     self.velocity.linear.x=0.1
                     self.velocity.angular.z= 0.0
                     self.action="Go Straight"

             self.publisher.publish(self.velocity)

         ## Subscriber Call Back
         def process_data(self, data):
```

```
            self.get_logger().info("Image Received!")
            frame = self.bridge.imgmsg_to_cv2(data)
            light_line = numpy.array([120,120,0])
            dark_line = numpy.array([150,150,10])
            mask = cv2.inRange(frame, light_line,dark_line)
            cv2.imshow('mask', mask)

            canny= cv2.Canny(mask,30,5)
            cv2.imshow('edge', canny)

            r1=200;c1=0
            img = canny[r1:r1+200,c1:c1+512]
            cv2.imshow('crop', img)

            edge=[]
            row =150

            for i in range(512):
                if(img[row,i]==255):
                    edge.append(i)
            print(edge)

            if(len(edge)==0):
                left_edge=512//2
                right_edge=512//2
                self.empty = True
            if(len(edge)==1):
                if edge[0]>512//2:
                    left_edge=0
                    right_edge=edge[0]
                    self.empty = False
                else:
                    left_edge=edge[0]
                    right_edge=512
                    self.empty = False
            if(len(edge)==2):
                left_edge=edge[0]
                right_edge=edge[1]
                self.empty = False
            if(len(edge)==3):
                if(edge[1]-edge[0]>5):
                    left_edge=edge[0]
                    right_edge=edge[1]
```

```
                    self.empty = False
                else:
                    left_edge=edge[0]
                    right_edge=edge[2]
                    self.empty = False
            if(len(edge)==4):
                left_edge=edge[0]
                right_edge=edge[2]
                self.empty = False

            if(len(edge)>=5):
                left_edge=edge[0]
                right_edge=edge[len(edge)-1]
                self.empty = False

            road_width=(right_edge-left_edge)
            frame_mid = left_edge + (road_width/2)
            mid_point = 512/2
            img[row,int(mid_point)]=255
            print(mid_point)
            self.error=mid_point-frame_mid
            img[row,int(frame_mid)]=255
            print(self.action)
            f_image = cv2.putText(img, self.action, (100,100),
cv2.FONT_HERSHEY_SIMPLEX, 1, (255,0,), 2, cv2.LINE_AA)

    def main(args=None):
        rclpy.init(args=args)
        node = LineFollower()
        rclpy.spin(node)
        rclpy.shutdown()

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

line_follower.py

```
            import numpy
            import rclpy
            from rclpy.node import Node
            from cv_bridge import CvBridge
            from sensor_msgs.msg import Image
            from geometry_msgs.msg import Twist
            import cv2
```

```
            class LineFollower(Node):
                def __init__(self):
                    super().__init__('line_follower')
                    self.bridge = CvBridge()
                    self.subscriber =
self.create_subscription(Image,'/camera1/image_raw',self.process_data
, 10)
                    self.publisher = self.create_publisher(Twist,
'/cmd_vel', 40)
                    timer_period = 0.2
                    self.timer = self.create_timer(timer_period,
self.send_cmd_vel)
                    self.velocity=Twist()
                    self.empty = False
                    self.error = 0
                    self.action=""
                    self.get_logger().info("Node Started!")

                def send_cmd_vel(self):
                    if(self.empty):
                        self.velocity.linear.x=0.0
                        self.velocity.angular.z= 0.0
                        self.action="Stop"
                    else:
                        if(self.error > 0):
                            self.velocity.linear.x=0.1
                            self.velocity.angular.z=0.1
                            self.action="Go Left"
                        elif(self.error < 0):
                            self.velocity.linear.x=0.1
                            self.velocity.angular.z=-0.1
                            self.action="Go Right"
                        elif(self.error==0):
                            self.velocity.linear.x=0.1
                            self.velocity.angular.z= 0.0
                            self.action="Go Straight"

                    self.publisher.publish(self.velocity)

                ## Subscriber Call Back
                def process_data(self, data):
                    self.get_logger().info("Image Received!")
                    frame = self.bridge.imgmsg_to_cv2(data)
                    light_line = numpy.array([120,120,0])
```

```
                    dark_line = numpy.array([150,150,10])
                    mask = cv2.inRange(frame, light_line,dark_line)
                    cv2.imshow('mask', mask)

                    canny= cv2.Canny(mask,30,5)
                    cv2.imshow('edge', canny)

                    r1=200;c1=0
                    img = canny[r1:r1+200,c1:c1+512]
                    cv2.imshow('crop', img)

                    edge=[]
                    row =150

                    for i in range(512):
                        if(img[row,i]==255):
                            edge.append(i)
                    print(edge)

                    if(len(edge)==0):
                        left_edge=512//2
                        right_edge=512//2
                        self.empty = True
                    if(len(edge)==1):
                        if edge[0]>512//2:
                            left_edge=0
                            right_edge=edge[0]
                            self.empty = False
                        else:
                            left_edge=edge[0]
                            right_edge=512
                            self.empty = False
                    if(len(edge)==2):
                        left_edge=edge[0]
                        right_edge=edge[1]
                        self.empty = False
                    if(len(edge)==3):
                        if(edge[1]-edge[0]>5):
                            left_edge=edge[0]
                            right_edge=edge[1]
                            self.empty = False
                        else:
                            left_edge=edge[0]
                            right_edge=edge[2]
                            self.empty = False
```

```
                    if(len(edge)==4):
                        left_edge=edge[0]
                        right_edge=edge[2]
                        self.empty = False

                    if(len(edge)>=5):
                        left_edge=edge[0]
                        right_edge=edge[len(edge)-1]
                        self.empty = False

                    road_width=(right_edge-left_edge)
                    frame_mid = left_edge + (road_width/2)
                    mid_point = 512/2
                    img[row,int(mid_point)]=255
                    print(mid_point)
                    self.error=mid_point-frame_mid
                    img[row,int(frame_mid)]=255
                    print(self.action)
                    f_image = cv2.putText(img, self.action, (100,100),
cv2.FONT_HERSHEY_SIMPLEX, 1, (255,0,), 2, cv2.LINE_AA)

            def main(args=None):
               rclpy.init(args=args)
               node = LineFollower()
               rclpy.spin(node)
               rclpy.shutdown()

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

7. Make changes in `setup.py`

`setup.py`

```
      from setuptools import find_packages, setup
      import os
      from glob import glob

      package_name = 'perception'

      setup(
         name=package_name,
         version='0.0.0',
         packages=find_packages(exclude=['test']),
         data_files=[
             ('share/ament_index/resource_index/packages',
```

```
                ['resource/' + package_name]),
            ('share/' + package_name, ['package.xml']),
            (os.path.join('share', package_name), glob('launch/*')),
            (os.path.join('share', package_name), glob('urdf/*'))
        ],
        install_requires=['setuptools'],
        zip_safe=True,
        maintainer='vipul',
        maintainer_email='vipul@todo.todo',
        description='TODO: Package description',
        license='TODO: License declaration',
        tests_require=['pytest'],
        entry_points={
            'console_scripts': [
                'capture=perception.capture_image:main',
                'line=perception.line_follow:main'
            ],
        },
    )
```

8. Rebuild the package and source it again

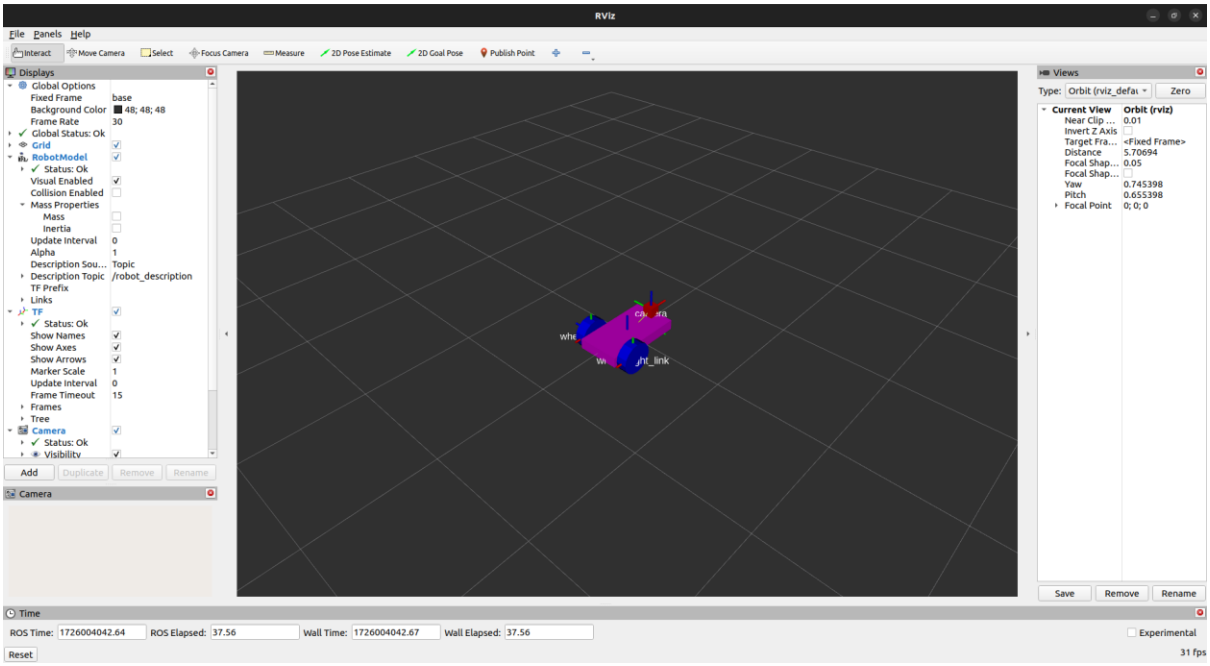
- `cd ~/ros2_ws/`
- `colcon build --packages-select perception`
- `source ~/ros2_ws/install/setup.zsh`

9. Launch rviz using the launch file and make the following changes

`terminal_1`

- `ros2 launch perception rviz.launch.py`

- Under `Global Options`, set `Fixed Frame` as `base`
- Click on `Add` at the bottom of the window and include `RobotModel`, `Camera` and `TF` (one at a time)
- Under `RobotModel`, set `Description Topic` as `/robot_description`
- Under `Camera`, set `Description Topic` as `/camera1/image_raw`



10. Place `model.config` and `model.sdf` in `~/.gazebo/models/yellow line`

`model.config`

```
<?xml version="1.0" ?>
<model>
<name>yellowline</name>
<version>1.0</version>
<sdf version="1.6">model.sdf</sdf>
<author>
<name></name>
<email></email>
</author>
<description></description>
</model>
```

model.sdf

```
<?xml version="1.0"?>
<sdf version="1.6">
<model name="yellow line">
<static>true</static>
<link name="link_ground">
<collision name="collision">
<geometry>
<plane>
<normal>0 0 1</normal>
<size>0.1 3.2</size>
</plane>
</geometry>
<surface>
<friction>
<ode>
<mu>100</mu>
<mu2>50</mu2>
</ode>
</friction>
</surface>
</collision>
<visual name="visual_ground">
<cast_shadows>false</cast_shadows>
<geometry>
<plane>
<normal>0 0 1</normal>
<size>0.5 10</size>
</plane>
</geometry>
<material>
<script>
<uri>file://media/materials/scripts/gazebo.material</uri>
<name>Gazebo/Yellow</name>
</script>
</material>
</visual>
</link>
</model>
</sdf>
```

11. Launch gazebo using the launch file, draw a line (insert→yellow line) and place the robot on the line

- `ros2 launch perception gazebo.launch.py`

12. Run the capture_image node, keep closing window to get a new image and press ctrl+c to capture a satisfactory image of the road

- `ros2 run perception capture`

13. Run the extract_road node in vscode directly and modify values of `light_line` and `dark_line` to get proper masking

```
light_line = numpy.array([120,120,0])
dark_line = numpy.array([150,150,10])
```

14. Modify the `line_follow.py` with the same values for `light_line` and `dark_line`. Then rebuild the package and source it again (Step 8)

15. Run the `line_follow` node (while gazebo is still running and yellow line is imported)

- `ros2 run perception line`