Congratulations! You passed!

TO PASS 75% or higher

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Module 4: Graded Quiz

LATEST SUBMISSION GRADE

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1. A single 3D LIDAR reading consists of elevation, azimuth and range measurements $(\epsilon, \alpha, r) = (5^\circ, 10^\circ, 4 \text{ m})$. Assuming that the measurements are noiseless, calculate the position of this point in the Cartesian sensor frame. Note that the elevation and azimuth angles are given in degrees (for convenience) - you will need to convert these values to radians for use with most trigonometric functions.

   2 / 2 points

   Enter your result in the area below as comma separated list of values, in the (x, y, z) format, e.g (1.22, 2.33, 3.44).

   (3.92424105, 0.69194958, 0.34862297)

   Correct

   Correct!

2. A 3D LIDAR unit is scanning a surface that is approximately planar, returning range, elevation and azimuth measurements. In order to estimate the equation of the surface in parametric form (as a plane), we need to find a set of parameters that best fit the measurements.

   3 / 3 points

   Implement the *sph_to_cat* and *estimate_params* functions, which transform LIDAR measurements into a Cartesian coordinate frame and estimate the plane parameters, respectively. You may assume that measurement noise is negligible. The code comments provide more information on the format of the arguments to each function.

```
from numpy import *

def sph_to_cart(epsilon, alpha, r):
  """
  Transform sensor readings to Cartesian coordinates in the sensor
  frame. The values of epsilon and alpha are given in radians, while
  r is in metres. Epsilon is the elevation angle and alpha is the
  azimuth angle (i.e., in the x,y plane).
  """
  p = zeros(3)  # Position vector
  p[0] = r * cos(alpha) * cos(epsilon)
```

```
    p[1] = r * sin(alpha) * cos(epsilon)
    p[2] = r * sin(epsilon)
    # Your code here

    return p

def estimate_params(P):
    """
    Estimate parameters from sensor readings in the Cartesian frame.
    Each row in the P matrix contains a single 3D point measurement;
    the matrix P has size n x 3 (for n points). The format is:

    P = [[x1, y1, z1],
         [x2, x2, z2], ...]

    where all coordinate values are in metres. Three parameters are
    required to fit the plane, a, b, and c, according to the equation

    z = a + bx + cy

    The function should return the parameters as a NumPy array of size
    three, in the order [a, b, c].
    """
    param_est = zeros(3)
    m = P.shape[0]
    A = vstack([[ones((m)), P[:, 0], P[:, 1]]]).T
    b = P[:, 2]
    a, b, c = linalg.inv(A.T.dot(A)).dot(A.T).dot(b)
    param_est[0] = a
```

Run

Reset

Correct

Good job!

3. Which of the following statements are true? Select any/all that apply. **1 / 1 point**

- [ ] Point-to-plane ICP is often used in environments that lack structure.
- [x] ICP is sensitive to outliers caused by moving objects.

  Correct

  Correct! Moving objects in the environment can cause incorrect matches between LIDAR scan points.

- [ ] Because the points in a 3D point cloud are defined in Euclidean space, estimating the transformation between two point clouds is possible using simple trigonometry.

4. You are testing an algorithm for LIDAR-based localization on a vehicle in a controlled environment. What are some of the things you need to take into account? Select any/all that apply.

1 / 1 point

- [x] When the vehicle is moving quickly, it is important to account for the time differences between individual LIDAR pulses.

  Correct

  Correct! This means that every single point in a LIDAR sweep is taken from a slightly different position and a slightly different orientation, and this can cause artifacts such as duplicated objects to appear in the LIDAR scans.

- [ ] We need to make sure the environment is well lit.

- [x] It is important to identify shiny and highly reflective objects in the environment, as LIDAR measurements of those objects may be invalid.

  Correct

  Correct! Shiny and polished surfaces may dramatically reduce the amount of light reflected back along the original beam direction. For example, if the surface is very shiny, like a mirror, the laser pulse might be scattered completely away from the original pulse direction.

- [ ] The LIDAR always needs to be positioned horizontally, as even a small tilt will cause measurement errors.

5. To estimate the motion of a self-driving car, it is necessary to transform LIDAR scan points from the sensor frame to the vehicle frame. The rotation of the vehicle frame with respect to the LIDAR frame is represented by the rotation matrix $\mathbf{C}_{vl}$. Given any point $\mathbf{p}_l^{(i)}$ in the LIDAR frame, and considering rotation only, which of these expressions correctly transforms the point into the vehicle frame?

1 / 1 point

- (●) $\mathbf{p}_v^{(i)} = \mathbf{C}_{vl}\,\mathbf{p}_l^{(i)}$
- ( ) $\mathbf{p}_v^{(i)} = (\mathbf{p}_l^{(i)})^T\,\mathbf{C}_{vl}$
- ( ) $\mathbf{p}_v^{(i)} = \mathbf{C}_{vl}^T\,\mathbf{p}_l^{(i)}$

  Correct

  Correct! The rotation matrix $\mathbf{C}_{vl}$ represents the transform from the LIDAR fo the vehicle frame. Since our points are in the LIDAR frame, the transform needs to be applied on the left.