Exercise 5 (v1.0.1) November 23, 2021

Submission online until **Tuesday, 30.11.2021, 11:55 a.m.**

Assignment 5-1: Euler Angle Rotations (2 Points)

(a) (1 Point) Given is a coordinate frame $\{A\}$. The coordinate frame $\{B\}$ is created from $\{A\}$ via rotation around the z-axis by $\frac{\pi}{2}$, then intrinsic rotation around the y-axis by $\frac{\pi}{2}$ and intrinsic rotation around the x-axis by $\frac{\pi}{2}$. Write down the whole formula (with all rotation matrices in the right order) to calculate ${}^{A}_{B}R$. Calculate ${}^{A}_{B}R$.

(b) (1 Point) Given is a coordinate frame $\{A\}$. The coordinate frame $\{C\}$ is created from $\{A\}$ via rotation around the z-axis by $\frac{\pi}{2}$, then extrinsic rotation around the y-axis by $\frac{\pi}{2}$ and extrinsic rotation around the x-axis by $\frac{\pi}{2}$. Write down the whole formula (with all rotation matrices in the right order) to calculate ${}^{A}_{C}R$. Calculate ${}^{A}_{C}R$.

Assignment 5-2: Rodrigues Rotations (3 Points)

Given is the axis-angle rotation vector $\Theta = (2, 2, 0)$.

(a) (0.5 Points) Calculate the unit vector of the rotation axis k and the angle θ

(b) (1.5 Points) Derive the rotation matrix R representing the same rotation, using the exponential map, and show, that your matrix is orthogonal.

(c) (1 Point) Given a vector $P_A = (1, 2, 3)$ Rotate Vector P_A by Θ using Rodrigues' formula

Provide calculation steps for each of the above tasks.

Assignment 5-3: Wheel speed calibration (5 Points)

You may use the simulation's ground truth localization topic for the following tasks (`/simulation/odom_ground_truth`). Make yourself familiar with the `nav_msgs/Odometry` message.

The goal of this task is to create a mapping between the car's electric motor revolutions and the wheel speed. The car's electric motor provides feedback ticks on the `/sensors/arduino/ticks` topic.

(a) (3 Points) Calculate the ratio between travelled distance and counted ticks of the model car (in meters per tick). Therefore perform an experiment. The car shall drive approx. $2m$ with a certain velocity and steering. Repeat the experiment with two different steering angles (at least 0.0 and (-1.0 or 1.0) in addition) and constant speed ($0.3\frac{m}{s}$). Do you see different results with different speeds? How does the steering angle affect the results? Report your experimental results in a table (speed, steering, tick / distance ratio). Put the table to your Pdf.

(b) (2 Points) Write a node which calculates and publishes the speed from the ticks. You may publish the speed using the `autominy_msgs/Speed` message. An easy way to estimate the velocity is to save the last x (i.e. 50) tick measurements (sliding window) and then calculate the mean velocity. You can assume that the ticks are published at a fixed rate (100 Hz). A suitable data structure can be a ring buffer, for instance from python's `collections` package using `deque(maxlen=x)`. Plot the velocities over time for a simulated vehicle which accelerates as quickly as possible for 3 seconds. You can use `rqt_plot` for this. Put the resulting plot (y-axis velocity in meters per second, x-axis time in seconds) in your final Pdf.