Introduction to Robotics Institut für Informatik, Freie Universität Berlin
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Exercise 5 November 12, 2019

Submission online until **Tuesday, 19.11.2019, 11:55 a.m.**

Assignment 5-1: Rotations (2 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) (0.5 Points) Derive the rotation matrix R representing the same rotation, using the exponential map, and show, that your matrix is orthonormal.

(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 5-2: Steering motor PWM calibration (2 Points)

After turning on the car the wheels can be turned manually. Turn the wheels fully to the left and right and monitor the values on the topic `/sensors/arduino/steering_angle` and find the minimum feedback values for steering to the left and to the right. Set the wheels back to a centered position. Now send messages on the topic `/actuators/steering_pwm` while still monitoring the steering feedback topic. Start with the PWM value of 1000 for steering to the left and 2000 for steering to the right. Decrease or increase these values until you reach the previously recorded feedback values for steering fully left or right. Which PWM values and feedback values did you get? Overwrite the values on the car in the file `~/ros-config.sh` with your values:

```
export ROS_MINIMUM_STEERING_FEEDBACK=165
export ROS_MAXIMUM_STEERING_FEEDBACK=405
export ROS_MINIMUM_STEERING_PWM=850
export ROS_MAXIMUM_STEERING_PWM=2100
```

You do not need to write Code for this task. Provide the values you found and the car's IP-address in your Pdf.

Assignment 5-3: Ceiling camera GPS (0 Points)

On the ceiling of the lab we installed 3 cameras to monitor the cars while driving and provide a GPS-like localization system. The localization system is running on the computer named `fisker`.

Every car is identified through an unique marker mounted on top of the car. There is a number on each marker indicating the id of the marker. If the localization system is running you can receive data from the localization system on the topic `/communication/gps/<ID>`.

In case the localization system is not running set up a catkin workspace on fisker and clone the following repository:

`https://github.com/stsundermann/camera_localization`

Build and source the workspace and start the localization system using

```
roslaunch camera_localization RoboticsLabLocalization.launch
```

Make sure the 6 markers on the floor are not covered and are visible to the cameras.

Assignment 5-4: Steering calibration (6 Points)

(a) (4 Points) Calibrate the steering angle of the car (bicycle model) by using the ceiling camera. Then set a normalized steering value (calibrate at least for -1.0, 0.0, 1.0) and drive some distance.

Calculate the turning radius R with respect to the center of the rear axle.

Calculate the steering angle of the virtual front wheel (in the middle).

The topic `/sensors/arduino/steering_angle` contains voltage measurements from the steering motor depending on the motor position. Subscribe to the topic and record the reported motor position during calibration.

Your code should allow the car to 1. take a measurement at the starting position, 2. to drive on a half circle or straight for 2 meters (when going straight). and 3. to take the second measurement, 4. finally to calculate the steering angle.

Write the measured values into a table. The first column should contain the 3 steering angle commands (-1.0, 0.0, 1.0), the second column contains the measured steering angles, the third column contains the reported motor position. Paste that table into your Pdf.

(b) (2 Points) Create a node that subscribes to `/sensors/arduino/steering_angle` and calculates the steering angle in radians. Upload the python code which performs the above experiments as well as the code which takes care of the steering angle mapping.