Exercise 10 January 17, 2022

Submission online until **Tuesday, 25 January 2022, 11:55 a.m.**

Assignment 10-1: Speed Controller - Part II (4 Points)

Implement a PID-controller for velocity control. Use `/simulation/odom_ground_truth` as velocity feedback signal. Use the weights for K_p, K_i, K_d from task 9-2. If you could not complete task 9-2, feel free to tune your own weights. The control output should be published at $100Hz$. Your controller should accept `autominy_msgs/SpeedCommand` messages as input.

Let the car drive continuously in a circle using a slight steering angle. Then let your controller perform the following actions in sequence:

(a) Stop the car

(b) Let the car accelerate to $0.2m/s$. Wait 3s

(c) Let the car accelerate to $0.5m/s$. Wait 3s

(d) Let the car accelerate to $0.8m/s$. Wait 3s

(e) Let the car decelerate to $0.2m/s$. Wait 3s

Create **one** plot containing the controller output, wanted speed and current speed (on Y-Axis in m/s) vs time (on X-Axis in s) of the above sequence. You can create the required plot conveniently using `rqt_multiplot`.

Assignment 10-2: Steering controller (4 Points)

Implement a PID control for the steering motor using the orientation from the localization system (`/simulation/odom_ground_truth`) as feedback. Your PID controller should accept a desired yaw angle (in map frame) as an input so that it can be used in later assignments. The control output should be published at $100Hz$. Your controller should accept `autominy_msgs/SteeringCommand` messages as input. Tune the controller weights K_p, K_d and K_i.

For testing let the car steer to a given constant orientation. At the start the car should be facing at least $\pi/2$ away from the desired orientation. As desired angles, set values of 0 or $\pm\pi$ (radian) so that the car will move as shown in the picture below.

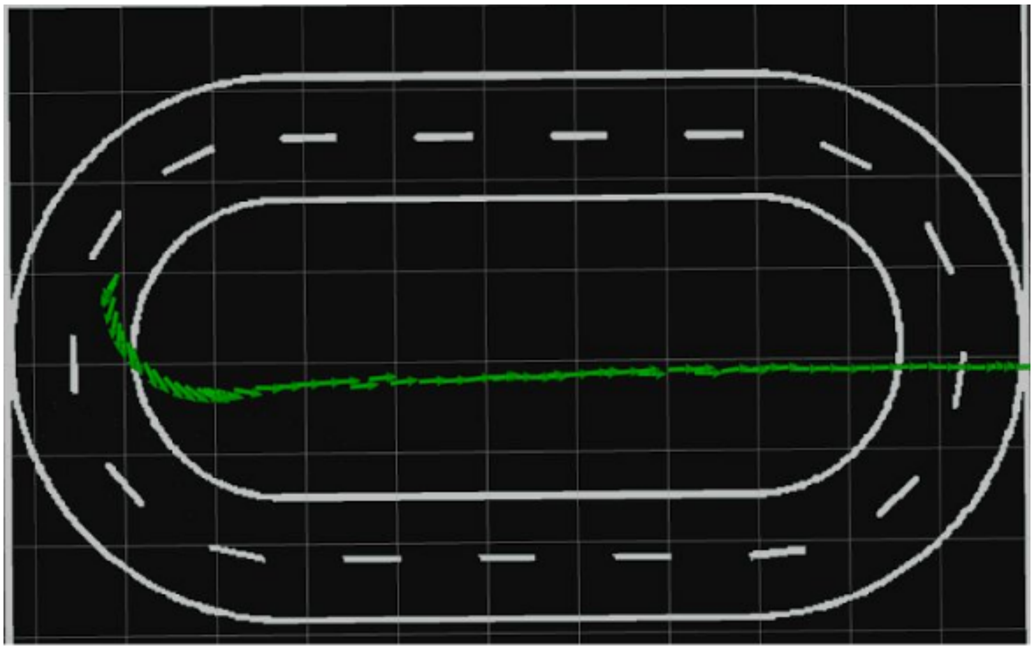


Figure 1: Example plotted path from controller output

Plot the driven path of at least one example of underdamped, overdamped, critically damped behaviour and your tuned result. You can plot the path by adding an odometry display for the feedback topic in `rviz`. Which values did you use for K_p, K_d and K_i?

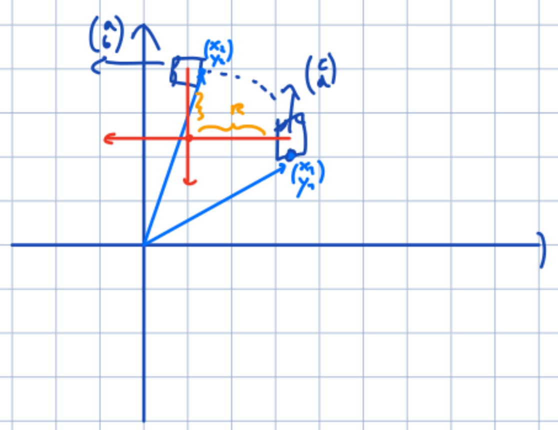
Assignment 10-3: Calculate odometry by hand (2 Points)

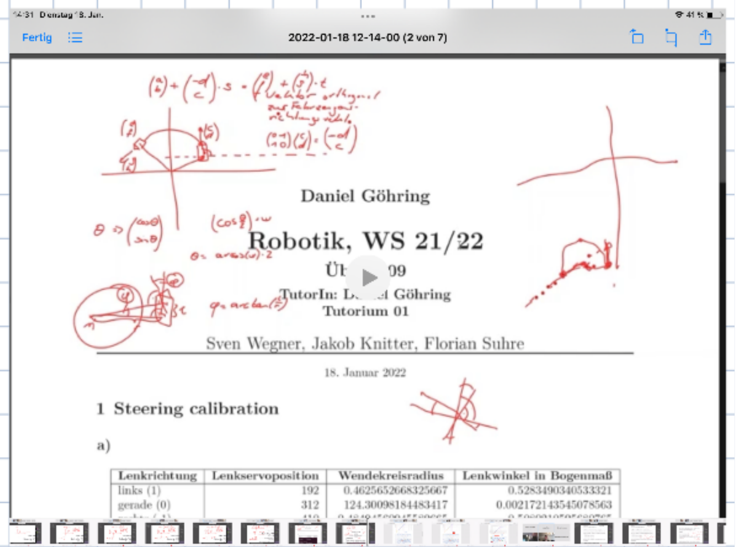
Solve this task manually (by hand, no ROS involved): Assume that your car is at starting position $(x_0, y_0) = (2, 1)$ (i.e., the center point of the rear axle) with angle $\theta_0 = \frac{\pi}{2}$. The wheel base (front axle to rear axle distance) of your vehicle is $0.27m$. Now assume, your car (i.e., the center point of the rear axle) travels a distance of $\frac{\pi}{2}m$ on a circle, maintaining a steering angle of 0.134189 radians (the angle of the virtual front wheel) w.r.t. the car's longitudinal axis. Calculate:

- the position of the instantaneous center of curvature
- the radius of the turning circle
- the vehicle's new position (x_1, y_1) and
- the new orientation angle θ_1.

Write down the calculation steps and your results in your Pdf.

$\begin{pmatrix} e \\ f \end{pmatrix} = \begin{pmatrix} -b \\ a \end{pmatrix}$ $\begin{pmatrix} g \\ h \end{pmatrix} = \begin{pmatrix} -d \\ c \end{pmatrix}$ $R \Rightarrow \begin{pmatrix} x_1 \\ y_1 \end{pmatrix} + \begin{pmatrix} g \\ h \end{pmatrix} t = \begin{pmatrix} x_2 \\ y_2 \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix} s$





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18. Januar 2022

1 Steering calibration

a)

Lenkrichtung	Lenkservoposition	Wendekreisradius	Lenkwinkel in Bogenmaß
links (1)	192	0.4625652668325667	0.5283490340533321
gerade (0)	312	124.30098184483417	0.002172143545078563

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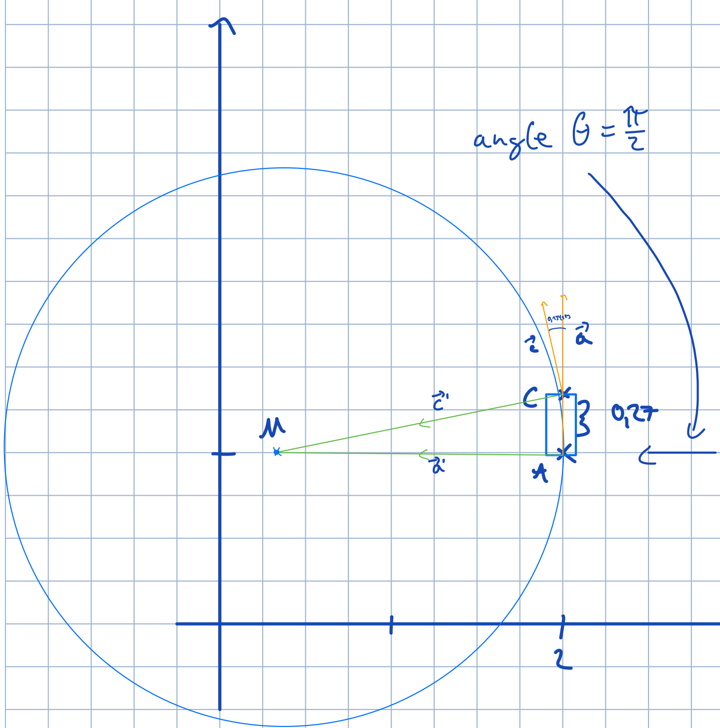
$\binom{a}{b}$ 90° drehen $\Rightarrow$ $\binom{b}{-a}$ or $\binom{-b}{a}$



BackW: $A = (2,1)$ $\vec{a} = \binom{0}{1}$ um 90° drehen $\Rightarrow$ $\vec{a}' = \binom{-1}{0}$

FrontW: $C = (2, 1{,}27)$, angle 0,134189 radians

$\vec{c} = \binom{0{,}134189}{1}$ um 90° drehen $\Rightarrow$ $\vec{c}' = \binom{-1}{-0{,}134189}$

53:40

1:07 $\Rightarrow$ 0,1

M: $A + \vec{a}'_t = C + \vec{c}'_h$

$$\binom{2}{1} + \binom{1}{0}t = \binom{2}{1{,}27} + \binom{1}{0{,}134189}h$$

I $\quad 2 + t = 2 + h \Rightarrow t = h$

II $\quad 1 + 0 = 1{,}27 + 0{,}134189h \Rightarrow h \approx -2$

M (instantaneous center of curvature) =

$$\binom{2}{1} + \binom{1}{0}t \text{ or } \binom{2}{1{,}27} + \binom{1}{0{,}134189}h$$

$$\binom{2}{1} + \binom{-2}{0} = \underline{\underline{(0,1)}}$$

Radius: (Abstand von zwei Punkten)

$$\begin{pmatrix} x_0 \\ y_0 \end{pmatrix} - \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

$$= \begin{pmatrix} 2 \\ 1 \end{pmatrix} - \begin{pmatrix} 0 \\ 1 \end{pmatrix} = |(2,0)| = \underline{\underline{2\,m}}$$

$\Rightarrow$ Kreisumfang $\pi d = 4\pi$

Es soll sich um $\frac{\pi}{2}$ m Gewegen

Also um $\frac{4\pi}{\frac{\pi}{2}} = \frac{\pi}{4}$ auf dem Kreisbogen

Neuer Autostandort

$$x = M_x + r \cdot \cos\frac{\pi}{4} = 0 + 2 \cdot \cos\frac{\pi}{4} = \sqrt{2}$$

$$y = M_y + r \cdot \sin\frac{\pi}{4} = 1 + 2 \cdot \sin\frac{\pi}{4} = 1 + \sqrt{2}$$

Neue Ausrichtung

$$\Theta_1 = \Theta + \frac{\pi}{4} = \frac{\pi}{2} + \frac{\pi}{4} = \frac{3\pi}{4}$$