ELEC 473 / ENGR 6412 Autonomy for Mobile Robots

Extended Kalman Filter programming assignment

You have received the attached data files from a fellow roboticist who ran a few tests using a UGV (unmanned ground vehicle) called LandTamer, outdoors. The LandTamer is a medium sized drive-by-wire UGV, built on the Deere eGator vehicle, and is well suited to operations on light off road terrain. The vehicle is Ackerman-steered. The LandTamer is retrofitted with a high end Novetel SPAN INS unit with RTK GPS.

Figure 1. RecBot with Novetel sensor on top of mast

The data files are formatted as follows.

Each line of data is either command data of the form:

Timestamp (s)	Commanded speed [i.e. v] (m/s)	Commanded curvature [i.e. κ] (m^{-1})	NaN	NaN	NaN	NaN	NaN	NaN

or sensor data of the form:

Timestamp (s)	NaN	NaN	x (m)	y (m)	z (m)	Roll (rad)	Pitch (rad)	Yaw [i.e. θ] (rad)

Hint: $\mathbf{C} = \mathbf{I}$

Hint: You can use dlmread to load the files in Matlab

There are 3 datasets, 1 driven on grass and 2 on gravel. For each dataset, a raw and a filtered file are provided. This refers to the Commanded speed (i.e. v) data. It is recommended you work with filtered data first, and then move on to working with raw data.

<u>The task</u>

Develop an EKF localizer that provides pose (x y θ) state estimates no less frequently than every 0.01s. In the absence of new sensor data, perform a motion (prediction) model update. At the arrival of new sensor data, interrupt with a motion (prediction) model update followed immediately by a sensor (correction) model update.

Use the following error parameters:

$$Q = \begin{bmatrix} 0.0025 & 0 & 0 \\ 0 & 0.0025 & 0 \\ 0 & 0 & 0.025 \end{bmatrix}$$

$\alpha_1 = \alpha_2 = 1$

$\alpha_3 = \alpha_4 = 0.1$

Initialize the state estimate using the first sensor reading. i.e.:

$$\mu_0 = z_{t=0}$$

$$\mathbf{\Sigma}_0 = Q$$

Hint: For post-processing analysis, it will be useful to also write a script that separates the sensor data (z_t) and the command data (u_t)

Assignment **Due Feb 18, 2020 at 5pm on Moodle**

1. Submit all of your code. Remember that Concordia's expectations of originality apply.

2. a) Provide the following plots for each of the 3 datasets:

- μ_x vs. t , z_x vs. t
- μ_y vs. t , z_y vs. t
- μ_θ vs. t , z_θ vs. t
- μ_x vs. μ_y , z_x vs. z_y
- det($\mathbf{\Sigma}$) vs. t (v_t vs. t, ω_t vs. t)

b) For the LandTamerLawn_raw dataset:

Plot:

- μ_θ vs. t , z_θ vs. t

zoomed in focusing on t=30 s to t=60 s.

3. a) For the LandTamerLawn_raw dataset, provide a very brief discussion of the det($\mathbf{\Sigma}$) vs. t plot and how it relates to the corresponding v_t vs. t and/or ω_t vs. t plots.

b) For the LandTamerLawn_raw dataset:

Plot:

- det($\mathbf{\Sigma}$) vs. t

zoomed in focusing on t=268 s to t=269 s.

Describe the various features of what is happening to the rover's state estimation uncertainty over the course of this timespan.

4. a) For the LandTamerLawn_raw dataset plot:

- μ_x vs. μ_y , z_x vs. z_y

zoomed in on the region [x ={-22, -19}, y = {6,9}]

b) Rerun the EKF on the LandTamerLawn_raw with $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 1e9$

Plot:

- μ_x vs. μ_y , z_x vs. z_y

zoomed in on the region [x ={-22, -19}, y = {6,9}]

c) Rerun the EKF on the LandTamerLawn_raw with $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 1e - 9$

Plot (not zoomed in):

- μ_x vs. μ_y , z_x vs. z_y

d) Compare and discuss the results in 3 (a)-(c). What is different about the plots and why are they different?