MTRN4010

OFFLINE approach for mitigating bias in measured angular rates

Gyroscopes' measurements are polluted by randomly fluctuating "white noise" plus by certain offset (bias).

$$\begin{cases} \tilde{\omega} = \omega + b + \eta, \qquad \eta \sim N\left(0, \sigma_{gyro}^2\right) \\ \tilde{\omega}(t) \ : \ \text{measured angular rate (polluted)} \\ \omega(t) \ : \ \text{actual angular rate} \\ \\ b \ : \ \text{constant bias} \quad \text{(usually unknown, may be slowly time variant)} \\ \eta(t) \ : \ \text{fluctuaning random noise (unknown, zero-mean, "white noise")} \end{cases}$$

Each of the 1D gyroscopes that compose a 3D gyroscope, is affected by this class of pollution.
(Each of them has usually different biases and different fluctuating noises.)

Now, we focus our attention on the case of a 1D gyroscope, but we should keep in mind that similar process does occur in each of them.
We can exploit the fact that if during some period the sensor is not moving, the sensor should, ideally, measure constantly nil angular rate; however, what is measured is the result of the contributions of the bias and the white noise. The white noise has average=0 (it is "zero mean"); consequently, the offset can be estimated by averaging the measurements during that period during which we know the sensor was static.
The averaging process during "calibration time", of duration T, will be $B = 1/T \cdot \int_{\tau=t_0}^{t_0+T} \omega_{measured}(\tau) \cdot d\tau$ (in our implementations, we will use a discrete time version of this integral)

The estimated bias, B, can be posteriorly used for removing (or at least mitigating) the bias in subsequent readings (e.g. when the sensor is being used for estimating the attitude), for improving results. Before using the measured angular rate, we remove the estimated bias, e.g.

$$\omega_{improved}(t) = \omega_{measured}(t) - B$$

In our datasets for Project 1, we know that all the recorded trips of the platform did have an initial calibration time of at least 5 seconds, since the dataset does begin. So, under that assumption our programs for Project 1 can perform a calibration process, at the beginning of the trip.

Why do we say that is "OFFLINE"? We would say that a parameters' estimation process is "ONLINE", if the process can perform the estimations of the parameters simultaneously with the estimation of the system states. The approach we discussed here requires running before we can start to estimate the state of the system.
We will see an ONLINE approach when we present the EKF (Extended Kalman Filter), in subsequent lectures. For the moment, for project 1, we will require the platform to stay static for an interval of time, to allow this calibration approach.

If you have questions, ask the lecturer via Moodle's Forum, or by email (Email: j.guivant@unsw.edu.au)