MTRN4010

Bias in measured angular rates
Integrating angular rates for 2D cases

Gyroscopes' measurements are polluted by randomly fluctuating noise and to certain offset (bias).
We can exploit the fact that, during some initial period of time, the sensor is not moving; consequently, the sensor should measure nil angular rate during that interval of time. Consequently, the offset can be estimated by averaging the read values, during an interval of time during which we are sure the sensor was static.
The estimated bias can be used for removing the bias in subsequent readings (e.g. when the sensor is actually moving), for improving results. Before using the measured angular rate, we remove the estimated bias, e.g.

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

For instance, for estimating the heading of the platform in which the sensor is installed,

$$\theta(t) = \theta(t_0) + \int_{\tau=t_0}^{t} \omega_{real}(\tau)\cdot d\tau \approx \theta(t_0) + \int_{\tau=t_0}^{t} \omega_{improved}(\tau)\cdot d\tau = \theta(t_0) + \int_{\tau=t_0}^{t} \left(\omega_{measured}(\tau) - B\right)\cdot d\tau$$

Note: we are integrating only the gyro Z, assuming $\frac{d\varphi_z(t)}{dt} = \omega_z(t)$, because we know that the platform operated on an almost flat surface and that the IMU is installed aligned to the platform.

As we are not able to sample at infinite rate but at a "fast enough" rate, i.e. 200Hz, we need to implement the integration in a numerical way.
Given certain rate $\alpha(t) = {dA(t)}/{dt}$, then its associated integral relation is $A(t) = A(t_0) + \int_{\tau=t_0}^{t} \alpha(\tau)\cdot d\tau$. The continuous process can be approximated by the following discrete-time process:

$$A(t_n) = A(t_0) + \sum_{i=1}^{n} \alpha(t_{i-1})\cdot(t_i - t_{i-1}).$$

This approximation is valid in cases in which $(t_i - t_{i-1})$ are small enough. The integration process can also be expressed in a recursive fashion, as follows,

$$A(t_k) = A(t_{k-1}) + \alpha(t_{k-1})\cdot(t_k - t_{k-1}).$$

This recursive process can be easily implemented in a computer program, and it can be exploited for integrating the heading rate in our problem.

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