Exercise on 22.01.2020

Task 1 *(5 Points)*

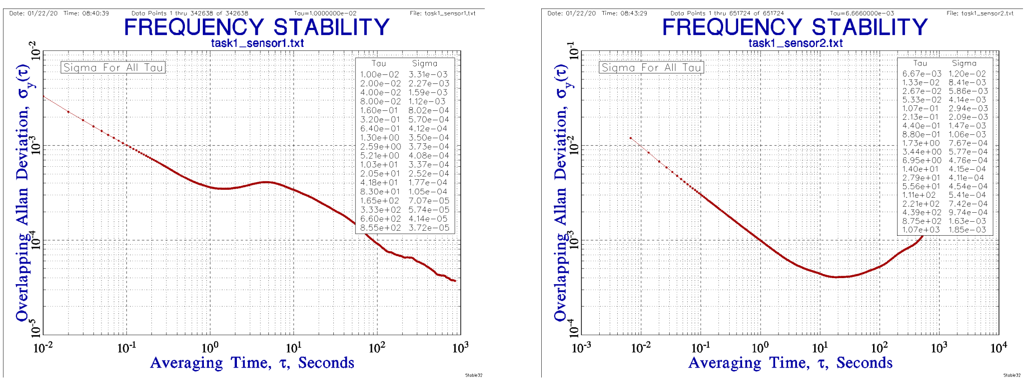
In order to examine the stability of initial sensors, the so-called Allan variance is used. For measurements given as a discrete time series $x(t)$ the Allan variance is computed by

$$\sigma_y^2(\tau) = \frac{1}{2\tau^2}\Big\langle (x(t+2\tau) - 2x(t+\tau) + x(t))^2 \Big\rangle$$

where the averaging operator $\langle . \rangle$ is applied for all possible triplets $(x(t+2\tau), x(t+\tau), x(t))$ of the time series. A detailed description is given on e.g. `http://cache.freescale.com/files/sensors/doc/app_note/AN5087.pdf`

On ILIAS you find measurements (`task1_sensor1.txt`, `task1_sensor2.txt`) from two acceleration sensors, which were recorded while the platform was not moving (Note: The readout frequency of `sensor1` is 100 Hz, the one of `sensor2` is 150 Hz). Compute the Allan variance $\sigma^2(\tau)$ for each sensor and plot your results in one (log-log) plot.
Describe the plots and at what you have to look at when choosing a sensor for an application (e.g. long time stability, short time stability).

Proposal for solution 1



(a) sensor1 (b) sensor2

Figure 1: Overlapping Allan Variance of given datasets.

One can see from the plots that sensor1 is more stable than sensor2 and the bias instability point was not reached. When choosing a sensor for a specific application one has to look in detail into the application requirements and have to find a balance between costs and stabilities. Some sensors also tend to be more stable on a short term than some long term stable sensors (e.g. see fig. 2).

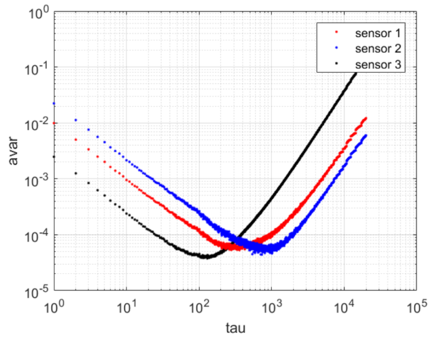


Figure 2: Other sensors

A detailed introduction into Allan Variance is given in "2007_Handbook_Riley.pdf" on ILIAS.

Task 2 *(5 Points)*

On ILIAS you will find a time series $\Delta v^p(t)$ for $t = t_1, t_2, t_3 \dots t_N \quad N = 1000$ (`task2_accel.txt`) which contains the change of velocities in a (fictive) 1D accelerometer which were recorded with a data rate of 100 Hz.
Compute the acceleration over time as it was shown in the lectures (see Eq. (9.10)), by using either $a^p(t_{k-2})$, $a^p(t_{k-1})$ or $a^p(t_k)$. Plot your results as function of t and describe the differences between them.

Proposal for solution 2