Measuring systems

Problem set 10

Data analysis

Exercise 1 (Estimate of the average)

We would like to calibrate a gyroscope. This is done by placing it on a motor driven at a known angular speed ω_{ref}. The obtained signal is sampled with the frequency f_{sam} during the period ΔT. The average value of each acquisition is then calculated. The measurement is repeated *N* times and the standard deviation of the averaged values $\sigma_{\bar{\omega}}$ is obtained.

a) What is the value of the standard deviation σ_{ω} for the measured angular velocity?
b) What is the value of the standard deviation of the averages if we quadruple the number of measurements *N*?
c) What should be the duration ΔT_2 of acquisition to achieve a standard deviation $\sigma'_{\bar{\omega}}$ of the averages?
d) What will be the standard deviation $\sigma''_{\bar{\omega}}$ of the averages if the sampling frequency is two times lower and the period is ΔT ?

Numerical values:

$\omega_{ref} = 50\ °/sec$ $N = 50$

$f_{sam} = 200\ Hz$ $\sigma_{\bar{\omega}} = 0.35\ °/s$

$\Delta T = 1\ sec$ $\sigma'_{\bar{\omega}} = 0.15\ °/s$

Exercise 2 (Types of error, confidence level and number of measurements)

We have measured 200 times the atmospheric pressure $P_{atm} = 1.0\ bar$ using a pressure sensor under the same conditions and found an average μ_P and standard deviation σ_P.

a) Find the fidelity (precision), accuracy and total error for $\boldsymbol{P_{atm}}$ with a confidence level p_0, p_1 and p_2.
b) What is the statistical error δ_α of $\boldsymbol{\mu_P}$ for a risk factor $\mathbf{2}\alpha$?
c) What is the number of measurements *N* needed to estimate the value of the pressure with error δ and risk of error 2α?

Numerical values:

$\mu_P = 1.6\ bar$ $p_0 = 68\ \%$

$\sigma_P = 0.15\ bar$ $p_1 = 95\ \%$

$\mathbf{2}\alpha = 10\ \%$ $p_2 = 90\ \%$

$\delta = 0.01\ bar$ $C = 1\ \mu F$