Strict submission deadline: 01 July 2024 at 10:00 am.
Submit a PDF or Word document for calculations and plots. Submit Matlab source code for Matlab programs.

Exercise #6

Task 6.1

Run the given Matlab program "robot_movement". Extend the program so that a Kalman filter calculates estimates of the robot's velocity. The program should plot the true velocity (ground truth), the robot's velocity readings, and the Kalman filter estimate of the velocity.

Task 6.2

A stationary random process z(ζ,t) with the mean $m_z^{(1)} = 0$, and the standard deviation $\sigma_z = 1$ has the autocorrelation function

$$s_{zz}(\tau) = k\, e^{-\alpha|\tau|} + c$$

Let a random process y (ζ, t)

$$y(\zeta, t) = \begin{cases} 0 & for\ t \le t_0 \\ \int_{t_0}^{t} z(\zeta, \lambda) d\lambda & for\ t > t_0 \end{cases}$$

a) Determine the constants k and c.
b) Determine the cross-correlation function $s_{zy}(t_1, t_2) = E\{z(\zeta, t_1)\, y(\zeta, t_2)\}$
c) Is the process y (ζ, t) at least weak stationary? Give a reason.

Task 6.3

a) Explain the difference between a random process, a random variable, a pattern function, and a process variable.
b) What is the fundamental prerequisite for a Matched Filter construction?
c) Assume a perfectly working Matched Filter. What is the output of that filter if the shape of the transmitted signal is a rectangular impulse?
d) How does the signal-to-noise ratio affect the bit error rate in a Matched Filter receiver? Please answer in only one sentence.
e) Write down the Wiener-Hopf equation and explain its parts.
f) Assume you should implement a Wiener-Kolmogorov filter. Give a reasoned decision, if a causal Wiener-Kolmogorov filter should be used, or if a non-causal filter should be applied.