

Lab 9

*School of Architecture, Civil and
Environmental Engineering*

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https://disal.epfl.ch/teaching/signals_instruments_systems/

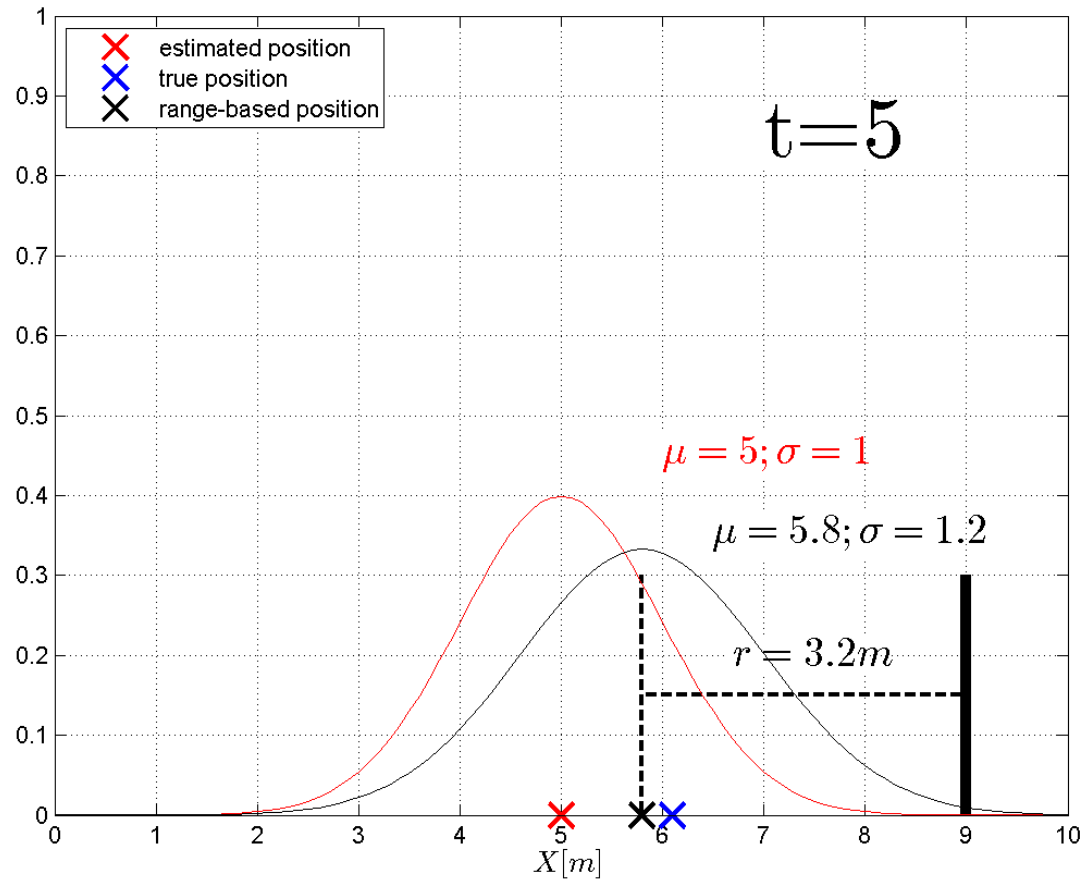
Outline

- Contents
 - Odometry with non-deterministic uncertainties
 - Feature based navigation
 - Sensor Fusion (Fraser Potter & Kalman Filter)
- Tools
 - Webots
 - C compiler
 - MATLAB

Getting Started

- Installation
 - Go to moodle and download:
Lab09 (.zip) and the assignment
- Starting with Webots
 - Launch Webots
 - Open World file for lab9
 - Clean + Build robot controller

Feature based navigation



1D Kalman Filter

Kalman Filter

Estimation Based on Motion Model
(prediction step)

$$\hat{x}_{k'} = \hat{x}_k + u[t_{k+1} - t_k]$$

$$\sigma_{k'}^2 = \sigma_k^2 + \sigma_w^2[t_{k+1} - t_k]$$

for Sensor and Motion Model Fusion
(update step)

$$\hat{x}_{k+1} = \hat{x}_{k'} + K_{k+1}(z_{k+1} - \hat{x}_{k'})$$

$$\sigma_{k+1}^2 = \sigma_{k'}^2 - K_{k+1} \sigma_{k'}^2$$

$$K_{k+1} = \frac{\sigma_{k'}^2}{\sigma_{k'}^2 + \sigma_z^2}$$

Algorithm **Kalman_filter**(μ_{t-1} , Σ_{t-1} , u_t , z_t)

1. Prediction:

$$\bar{\mu}_t = A_t \mu_{t-1} + B_t u_t$$

$$\bar{\Sigma}_t = A_t \Sigma_{t-1} A_t^T + R_t$$

4. Correction or update:

$$K_t = \bar{\Sigma}_t C_t^T (C_t \bar{\Sigma}_t C_t^T + Q_t)^{-1}$$

$$\mu_t = \bar{\mu}_t + K_t (z_t - C_t \bar{\mu}_t)$$

$$\Sigma_t = (I - K_t C_t) \bar{\Sigma}_t$$

8. Return μ_t , Σ_t

In the previous slide:

- $A_t = 1$
- $B_t = 1$

Here C_t maps a state $\tilde{\mu}_t$ to its equivalent measurement form $\tilde{z}_t$:

$$\tilde{z}_t = C_t \tilde{\mu}_t$$

Feedback for Lab 9

Please help us improve the labs by giving us feedback.

Thank you and enjoy the lab!