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Development and Research on Innovative Vocational Education Skills

SENSOR FUSION EXPERT

SFE.U4.E4 - FILTERING

Data and Sensor Fusion Applications, Use Cases and Real-Life Examples

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The student is able to …

SFE.U4.E4.PC1	The student understands and demonstrates the nature and purpose of filtering.
SFE.U4.E4.PC2	The student is able to describe the essential properties of the Kalman filter.
SFE.U4.E4.PC3	The student understands, compares and distinguishes the different types of Kalman filters.
SFE.U4.E4.PC4	The student knows the different use cases of each type of Kalman filter.
SFE.U4.E4.PC5	The student is able to describe the essential properties of Particle filters.
SFE.U4.E4.PC6	The student is able to critically select a suitable filtering technique to a specific problem depending on the type of system dynamics and noise characteristics.
SFE.U4.E4.PC7	The student is able to develop Kalman as well as Particle filtering algorithms for solving sensor fusion problems.

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Introduction

- The methods presented in the previous slides do not solve the estimation problem in the static case, but not when the parameters (ie, the states) vary between samples.
- So new methods are needed, which are able to combine:
  - The previous dynamic model information
  - Measurements at different points in time.

Introduction

- This process is called filtering.
- In these slides we will focus specifically on Kalman filter approaches.

What is the Kalman Filter

- Kalman Filters are used for mid-level sensor fusions, the most common in autonomous driving.
- As explained earlier, mid-level mergers are used to merge detections.
- Invented in 1960, the Kalman filter is used on mobile phones or satellites for navigation and tracking.

When can it be used?

- This filter can be used for data merging for the purpose of:
  - Estimate the state of a dynamic system
    - (evolving with time) in the present (filtering),
    - in the past (smoothing) or
    - in the future (forecast).

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When can it be used?

- Autonomous vehicle sensors emit measurements that are sometimes incomplete with noise.
- Sensor inaccuracy, also called noise, is a very important problem and can be handled by Kalman filters.

How it works?

- Kalman's is used to estimate the state of a system, denoted by x.
- This state vector is composed of a position p and a velocity v.

$$x = \begin{pmatrix} p \\ v \end{pmatrix}$$

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When can it be used?

- To each estimate, a measure of uncertainty P is associated.
- Using uncertainty is great because we can consider the fact that LiDARs are more accurate than RADARs in our measurements!
- When performing a data fusion, the sensor noise and outputs are considered.

Existing models:

- The Kalman Filter consists of:
  - Linear Kalman filter
  - Extended Kalman Filter
  - Unscented Kalman Filter
  - Particle Filter

Which is?

- It is a sequential Monte Carlo method that allows a complete representation of the state distribution.
- For this, sequential importance sampling and resampling is used.
- EKF and standard UKF make a Gaussian assumption in order to simplify the optimal recursive Bayesian estimate.
- But particle filters make no assumptions about the shape of the probability densities in question.

Which is?

- Therefore, they employ complete non-Gaussian non-linear estimation

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Thank you for your attention

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The aim of the Blueprint is **to support an overall sectoral strategy and to develop concrete actions to address short and medium term skills needs.**

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