SENSOR FUSION EXPERT

SFE.U4.E3 - ESTIMATION THEORY AND

ESTIMATION ALGORITHMS

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

JUNE 2021, Version 1

LEARNING OBJECTIVES

The student is able to …

SFE.U4.E3.PC1	The student understands and demonstrates the need, purpose, and outcomes of estimation theory.
SFE.U4.E3.PC2	The student is able to identify and explain the differences between linear, nonlinear and state space models.
SFE.U4.E3.PC3	The student knows the different use cases of each type of estimation algorithm.
SFE.U4.E3.PC4	The student is able to select the right estimation algorithm to a specific problem or situation.
SFE.U4.E3.PC5	The student can apply estimation algorithms and assess their behaviour.

Introduction

- The estimation algorithm gathers all available measurements using measurement models to estimate the parameters (or states) so that it is quite acceptable with respect to some criterion.
- This criterion is defined by a cost function.

Introduction

- The cost function is selected here to be the least squares cost function.

- That is, by bringing together information from various measurements and sensors, the diversity of measurements can be explored.

- This happens to get a better parameter estimation.

Introduction

- In summary, sensor fusion algorithms can in essence be considered as an application of estimation theory, which provides a statistically solid and flexible framework.

STATIC LINEAR MODELS

- They are very versatile models

- They have several important properties.

- Mainly the fact that a closed-form estimation algorithm can be found

STATIC LINEAR MODELS

- Static linear models are composed of:

  - Linear Model

  - Linear Least Squares

  - Regularized Linear Least Squares

  - Sequential Linear Least Squares

STATIC LINEAR MODELS

- These models are used in approaches that use:

  - Scalar Models

  - Vector Models

  - Affine Models

STATIC LINEAR MODELS

- For these models it is possible to analytically determine the properties of the estimators, such as bias or covariance.

STATIC NONLINEAR MODELS

- A static nonlinear model can be more accurate in describing the relationship between sensor measurements and the parameters of interest.

STATIC NONLINEAR MODELS

- The following components are part of these models:

  - Non Linear Model

  - Gauss–Newton Algorithm

  - Gauss–Newton Algorithm with Line Search

  - Levenberg–Marquardt Algorithm

  - Quasi-Newton Methods

  - Convergence Criteria

STATIC NONLINEAR MODELS

- These models are used in approaches that use:
  - Gauss measure noise

STATE SPACE MODELS

- Most of the sensor fusion have the particularity of holding variables that change dynamically.

- In the case of autonomous driving, there are objects that appear, disappear or just move, and this causes dynamically changing parameters to be estimated.

- These parameters are named after the state or state in which a certain system is.

STATE SPACE MODELS

- As these states undergo changes, it can be concluded that the system undergoes changes so the states are different from each other.

- This evolution follows a dynamic process, and they are related and with that these states can be related twice to each other.

- For this to happen, a way to describe how the state evolves between certain samples is needed.

STATE SPACE MODELS

- For continuous time processes, the approach to be used must be in differential equations

- For discrete-time processes, difference equations can be used that can describe dynamic time processes.

- Differential equations must be used to derive state space models that transform a differential (or difference) equation of order L into a differential (or difference) equation evaluated by a first order vector.

STATE SPACE MODELS

- State Space Models consist of:
  - Continuous-Time State-Space Models
  - Discrete-Time State-Space Models
  - Discretization of Linear Dynamic Models
  - Discretization of Nonlinear Dynamic Models

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This Training Material has been certified according to the rules of **ECQA – European Certification and Qualification Association.**

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Thank you for your attention

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