Estimation and the Kalman Filter (KC-1)
Course Content

Day 1:

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   - 1.2. Bibliography

2. **Models of Sensors, Processes and Uncertainty**
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     - 2.1.1. Conditional Probability Distributions
     - 2.1.2. Independence and Conditional Independence
   - 2.2. Bayes Theorem
     - 2.2.1. Estimation using Bayes Theorem
     - 2.2.2. Recursive Estimation Using Bayes Theorem
   - 2.3. The Expectation Operator
   - 2.4. Correlations and Power Spectra
     - 2.4.1. Autocorrelation and Autocovariance
     - 2.4.2. Stationarity
     - 2.4.3. Ergodicity
     - 2.4.4. Power Spectral Density
     - 2.4.5. Systems Driven by White Noise
   - 2.5. Process Models
     - 2.5.1. Linear State Transitions
     - 2.5.2. Non-Linear State Models and Linearisation
   - 2.6. Sensor Models
     - 2.6.1. Linear Sensor Models
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3. **Introduction To Estimation**
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   - 3.2. Estimation Methods
     - 3.2.1. Maximum Likelihood and Maximum *a posteriori* Rules
     - 3.2.2. Least Squares and Minimum Mean Squared Estimation
   - 3.3. The Relation Between Different Estimators
   - 3.4. Linear Estimators
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Laboratory 1: Modelling Sensors and Processes

Day 2:

4. The Linear Discrete-Time Kalman Filter
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- 4.2. Definitions
- 4.3. Description of the Problem
- 4.4. The Unbiased Condition
- 4.5. Calculation of the Error Covariance
- 4.6. The Choice of Gain
- 4.7. Summary
- 4.8. The Innovation

5. Understanding the Kalman Filter
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- 5.2. The Kalman Filter as a Weighted Average
- 5.3. The Kalman Filter as an Observer
- 5.4. The Kalman Filter as a Projection Operation
- 5.5. The Continuous Filter and it's Frequency Domain Interpretation

6. Implementing the Kalman Filter
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- 6.3. Steady State Performance
- 6.4. Filter Consistency
- 6.5. Validating Sensor and Process Models
  - 6.5.1. Incorrect Estimation of Process Error Model
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  - 6.5.3. Model Mismatch and the Use of Stabilising Noise
- 6.6. Steady State Filters

Laboratory 2: The Linear Kalman Filter – target tracking

Day 3:

7. The Extended Kalman Filter

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  - 7.1.2. State Prediction
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  - 7.1.4. Update Equations
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- 7.2. Understanding the Extended Kalman Filter
- 7.3. Implementation of the Extended Kalman Filter
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- 7.4. Limitations of Extended Kalman Filter
- 7.5. Alternatives to the Extended Kalman Filter

8. Example Implementation of the Extended Kalman Filter

- 8.1. The Process Model
  - 8.1.1. Nominal Process Model
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  - 8.8. Errors and Faults
  - 8.9. Tuning Filter Parameters

Laboratory 3: The Extended Kalman Filter – an autonomous land vehicle navigation system