Lecture 1

Optimal Estimation Theory and Its Applications

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Preface

Why you choose this course?

- Tutor's requirement
- Senior students' suggestion
- Interest in course synopsis
- Its usage in applications
- Teacher's kindness
- Academic promotion
- ... ...

Preface

- Estimation Definition
- Typical Applications
- Suggested References
- Course Requirements

Preface——Estimation Definition

The measurements, usually from sensors, contains random inaccuracies or be contaminated by unwanted signals; the estimator is thus necessary in order to eliminate as much of the inaccuracies or unwanted signals as possible through processing of the measurements. (B.D.O.Anderson & J.B. Moore, Optimal Filtering, Prentice-Hall, Inc., 1979)

Optimal estimation is the problem of casting into a useful information from an inherently noisy and substantially uncooperative environment. (Frank L. Lewis, Lihua Xie, Dan Popa, Optimal and Robust Estimation: with an introduction to stochastic Control Theory, Second Edition, CRC Press, 2007)

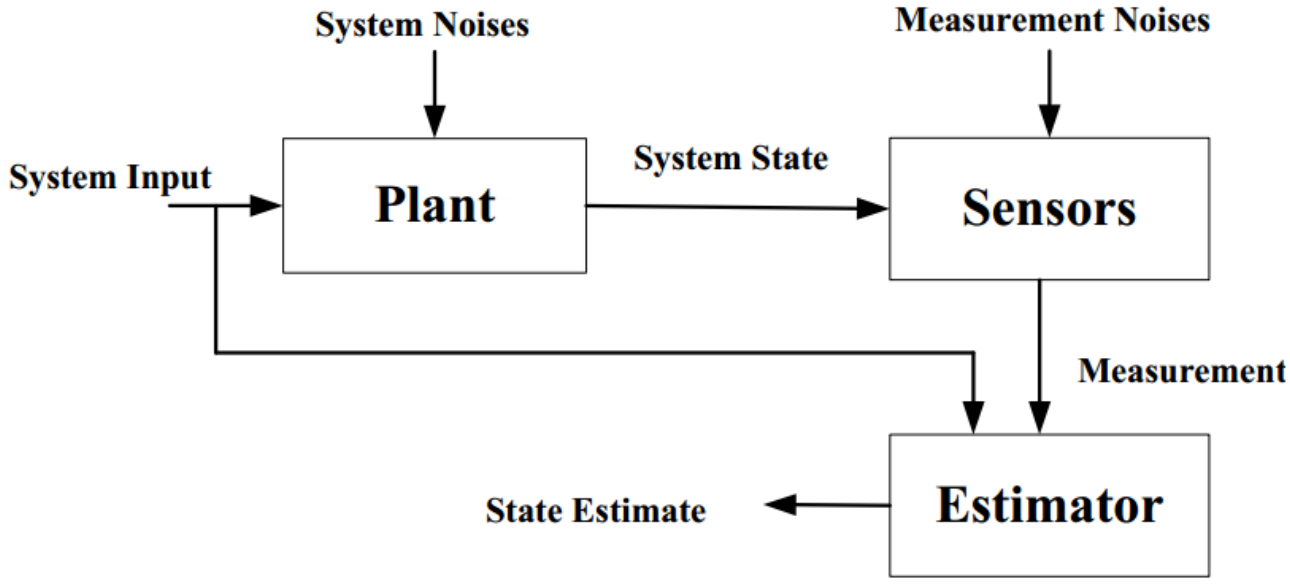
Optimal estimation, system identification, and optimal control constitute the foundation of the control discipline.

Preface——Estimation Definition

Given the measurement $Z(X)$ related to the unknown quantity X , construct the function $f(Z(X))$ as the estimate of X so that the distance between $f(Z(X))$ and X is the shortest in a certain distance measure.

1. Does $Z(X)$ have the same dimension of X ?
2. Does such estimate exist ?
3. Is such estimate unique ?

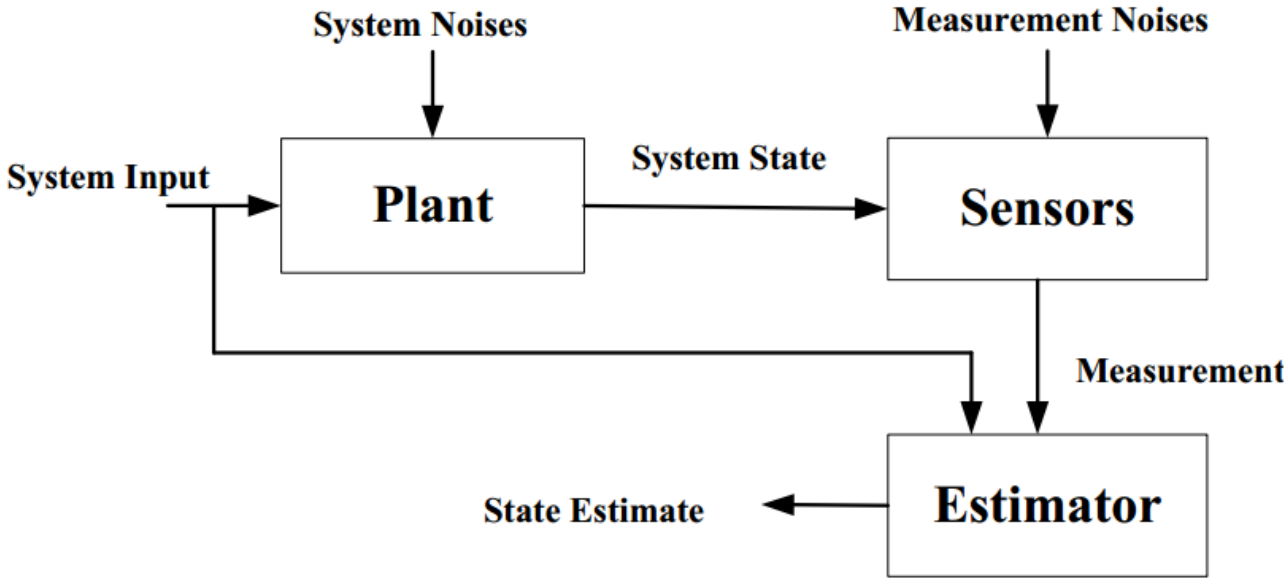
Preface——Estimation Definition



The estimator is sometimes called "soft sensor" measuring the interested states, which are not directly observed by the sensors.

Question: In which case does the estimate equal to the state ?

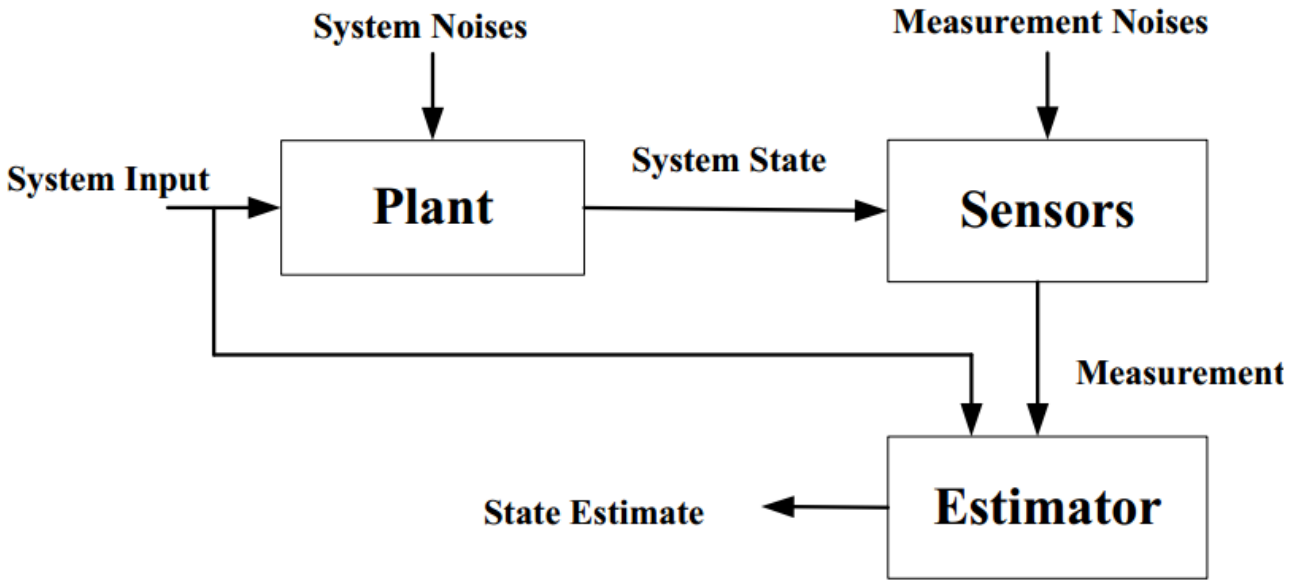
Preface——Estimation Definition



Noises widely exist, representing the modeling errors, external disturbance, unexpected faults.

Preface——Estimation Definition

The estimate is always different from the state due to random noises.



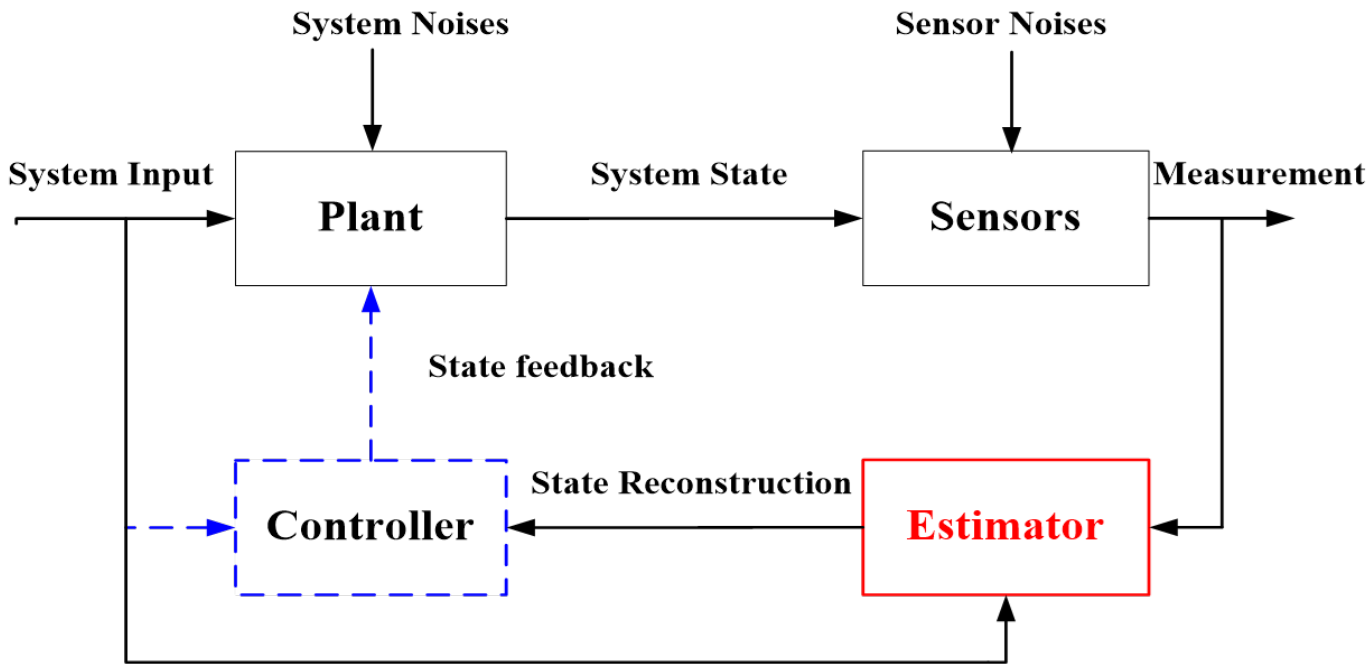
Preface——Typical Applications

In general, Estimation Theory is widely applied in the military and civil field:

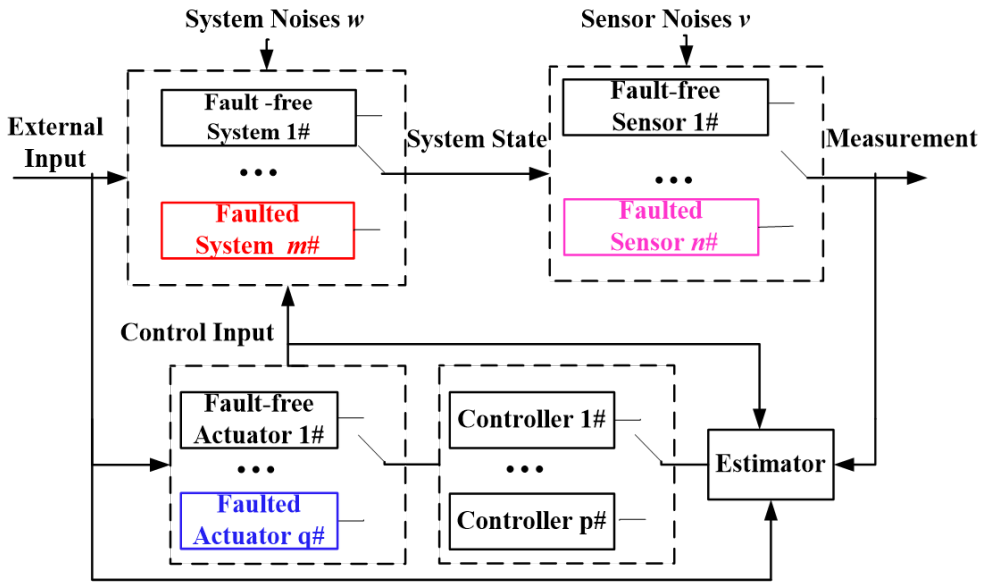
- Aerospace
- Surveillance
- Navigation
- Industrial process
- Communication
- Information processing
- Econometrics
- Robot

Preface——Typical Applications

For linear stochastic systems with additional white noises, its optimal controller and estimators can be designed separately.



Preface——Typical Applications



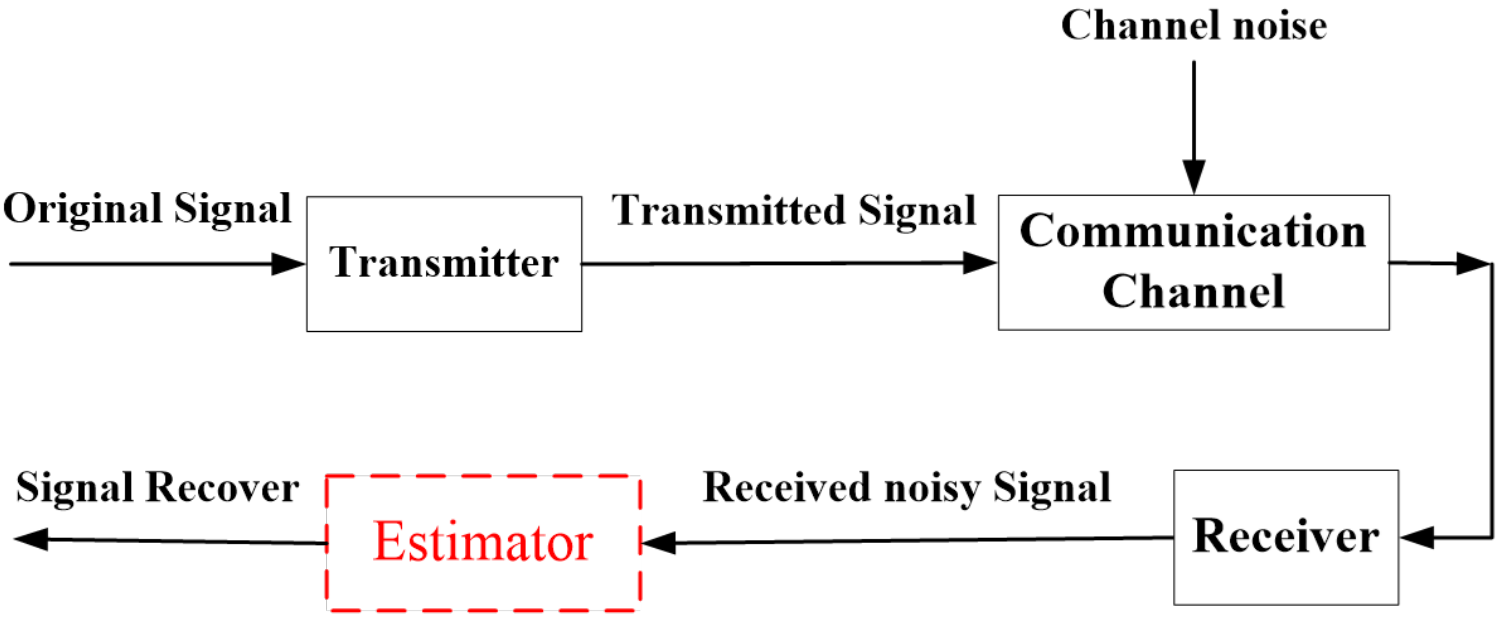
Fault Diagnosis and Fault-tolerant Control

$$x_{k+1} = (A_k + A_k^f)x_k + B_{1,k}u_{1,k} + \Gamma_k w_k + (B_{2,k} + B_{2,k}^f)u_{2,k}$$

$$z_k = (C_k + C_k^f)x_k + v_k$$

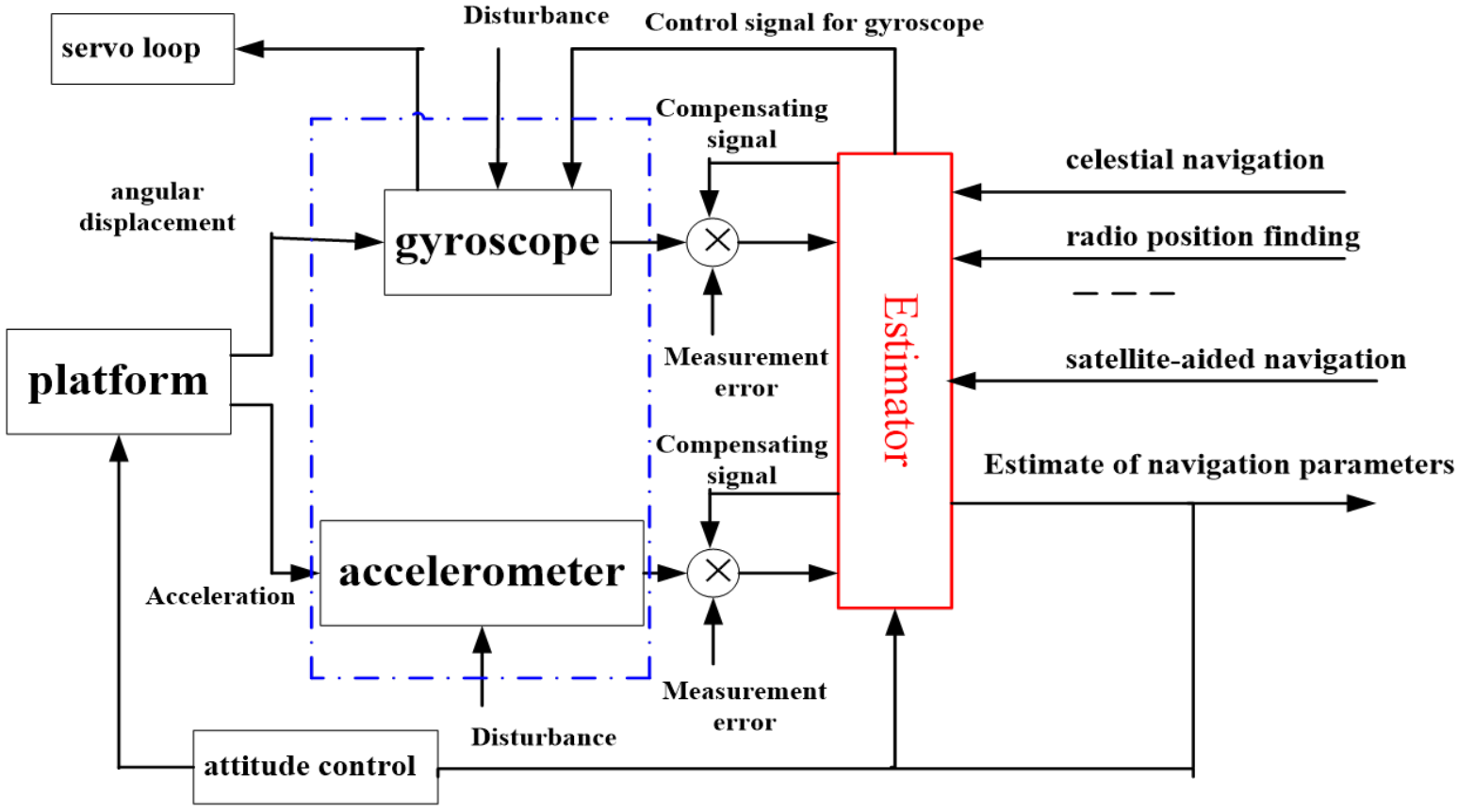
$$u_{2\ k} = K_k \hat{x}_k$$

Preface——Typical Applications



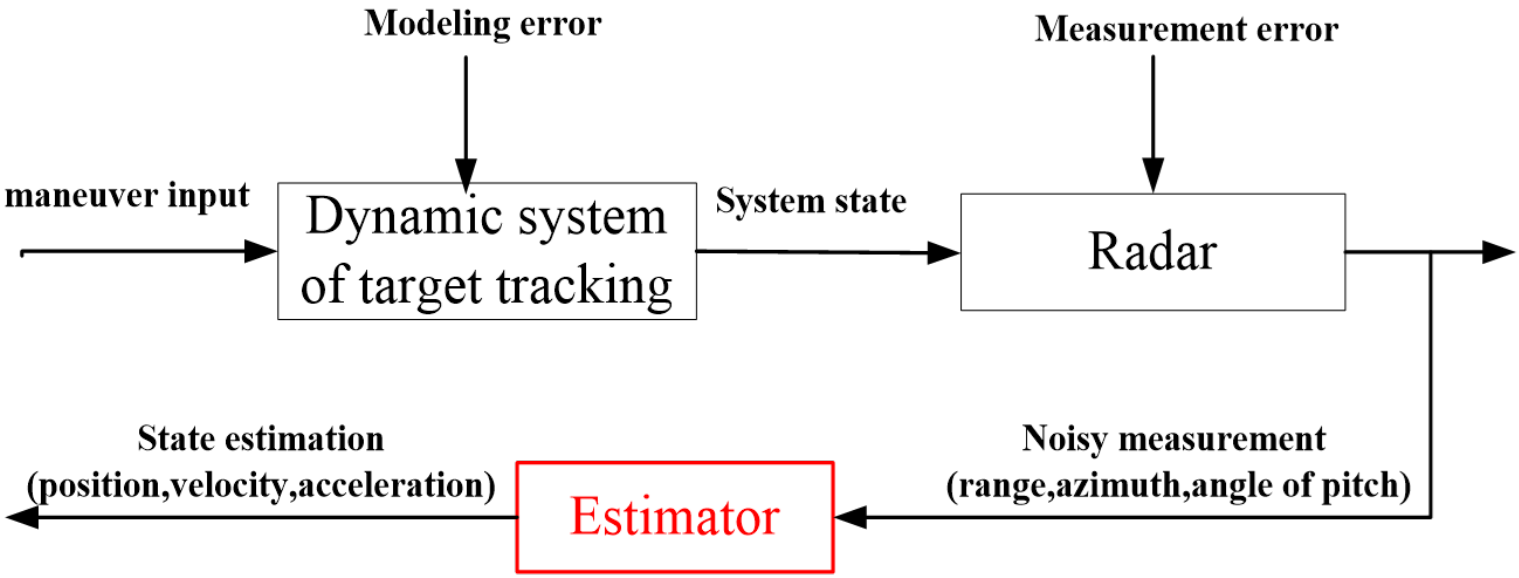
Estimation in Communication Systems

Preface——Typical Applications



Estimation in integrated navigation systems

Preface——Typical Applications



Estimation in Target-tracking Systems

Preface——Suggested References

- Frank L. Lewis, Lihua Xie, Dan Popa, **Optimal and Robust Estimation: with an introduction to stochastic Control Theory**, 2nd Edition, 2007
- Mohinder S. Grewal and Angus P. Andrews, **Kalman Filtering: Theory and Practice Using MATLAB**, 2nd Edition, 2001.
- Barshalom,Y. **Estimation with applications in tracking and navigation**, 2001.
- Simon D. **Optimal State Estimation: Kalman, H-infinity, and Nonlinear Approaches**, John Wiley & Sons, 2006
- B.D.O.Anderson & J.B. Moore, **Optimal Filtering**, 1979

Preface——Suggested References

Foreign electrical journal database (from our libiary)

- IEL(IEEE/IEE)
- Elsevier Science Direct
- International journal navigation

  `http://202.117.255.182:8080/was40/xwdh.html`
- SCI academic journal list

  `http://www.nwpu.edu.cn/web/tusg/dfw/ckzx/SCIckzn/`

Preface——Suggested References

- IEEE Trans. on Automatic Control
- IEEE Trans. on Signal Processing
- IEEE Trans. on Control Systems Technology
- IEEE Trans. on Aerospace and Electronic Systems
- AIAA Journal of Guidance Control and Dynamics
- IEEE Signal Processing Letters
- International Journal of Nonlinear and Robust Control
- International Journal of Control
- Control Engineering Practice
- IET Control Theory and Applications
- IET Radar, Sonar and Navigation
- IET Signal Processing

System Control Letters

Information Fusion

Information Sciences

Signal Processing

Automatica

Preface——Course Requirements

contents

1. Estimation principle and methods (include self-learning)
2. Method simulation and analysis (finish homework)
3. Academic discussion (submit and report your work)

Your work could be

- reference collection and translation
- your method application