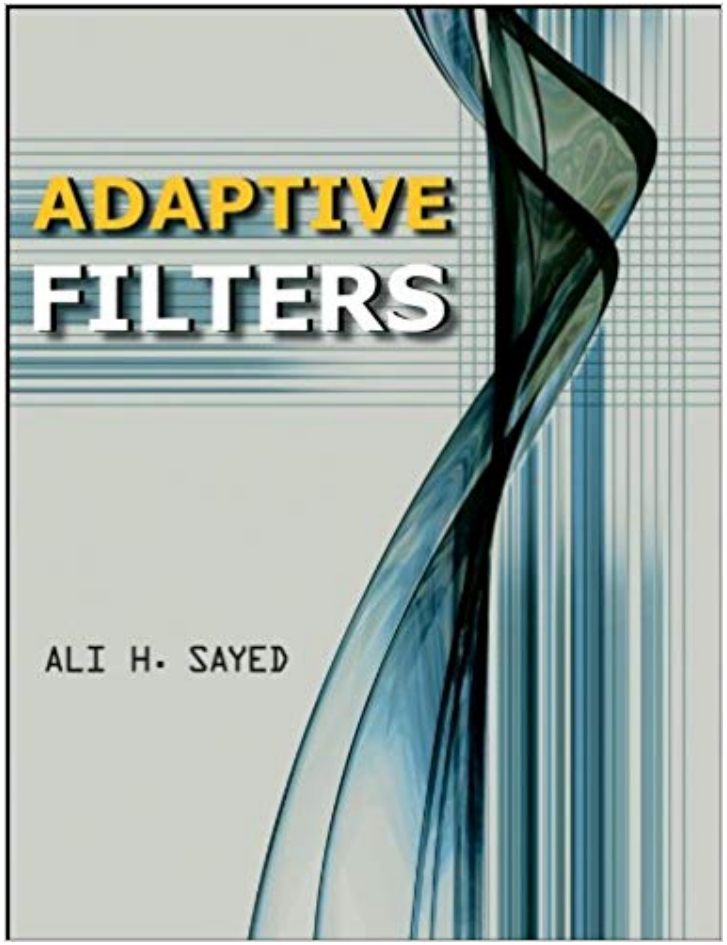
E9 211: Adaptive Signal Processing

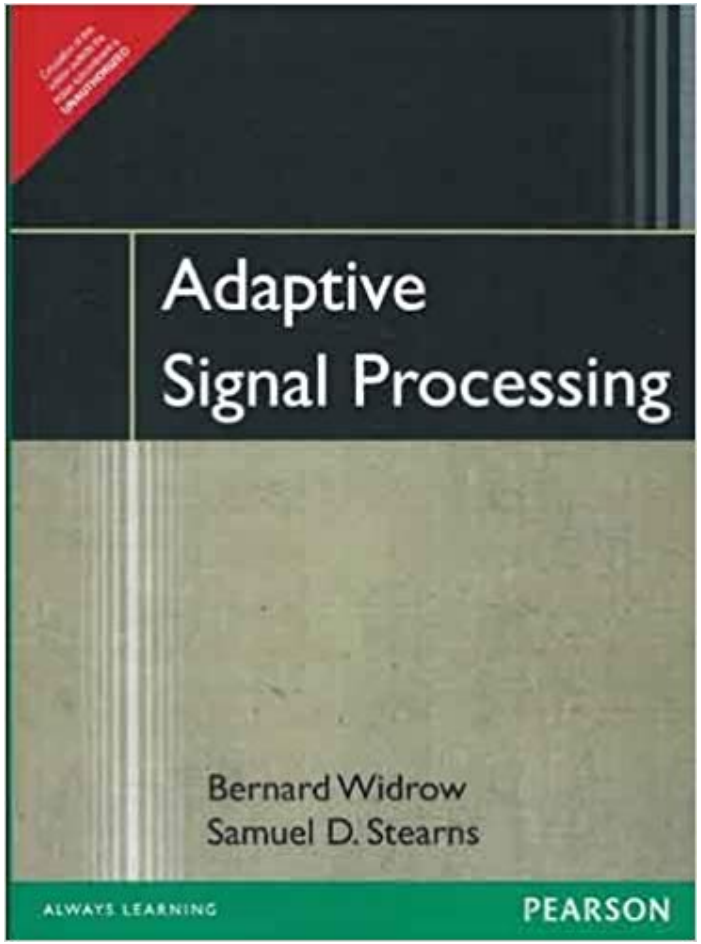
Lecture 1: Introduction

Course information

- Instructor:
  - Sundeep Prabhakar Chepuri.
    Email: spchepuri@iisc.ac.in
- Exercise sessions:
  - Prasobh Sankar.
- Class schedule:
  - Tuesdays and Thursdays 11.45 am - 1.15 pm.
- Course webpage:
  https://ece.iisc.ac.in/∼spchepuri/classes/e9211.html

Textbooks





Other resources:

- Adaptive Filter Theory, Simon Haykin, fourth edition, Pearson India.
- Adaptive Signal Processing: Next-Generation Solutions, Tülay Adali and Simon Haykin, Wiley-India edition.

Grading and course requirements

- **Three homeworks** (programming): 10% each, i.e., 30% in total
  - Mandatory to participate in the final exam and to pass the course.
  - Prepare reports using LaTeX.
  - Submit only pdf files. Include Matlab scripts as appendices. Word documents will not be graded.
  - Late submissions are allowed, but will not be graded.

- **Midterm exam** on December 3, 2020: 20%
  - Open book exam. 24 hour turn in time.
  - Syllabus covered till 19-11-2020, i.e., till and including Steepest-descent method.

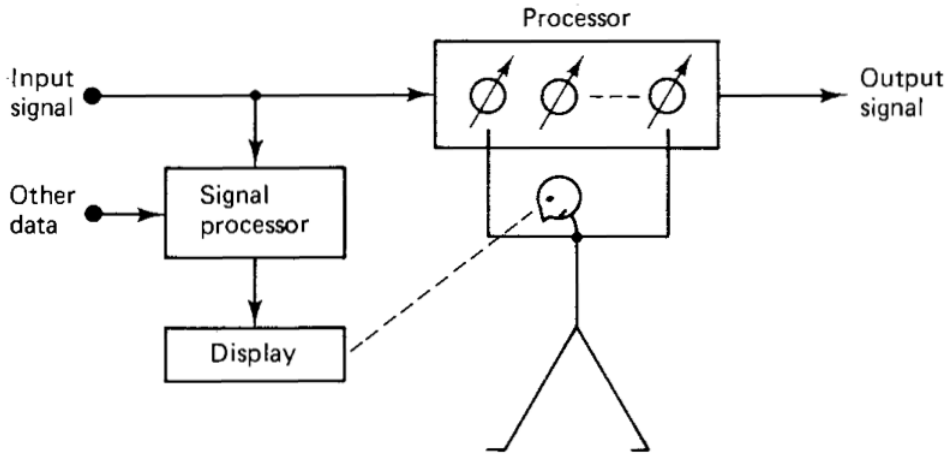
- **Project**: 30%
  - Prepare reports using LaTeX.
  - Submit only pdf files. Include Matlab scripts as appendices. Word documents will not be graded.

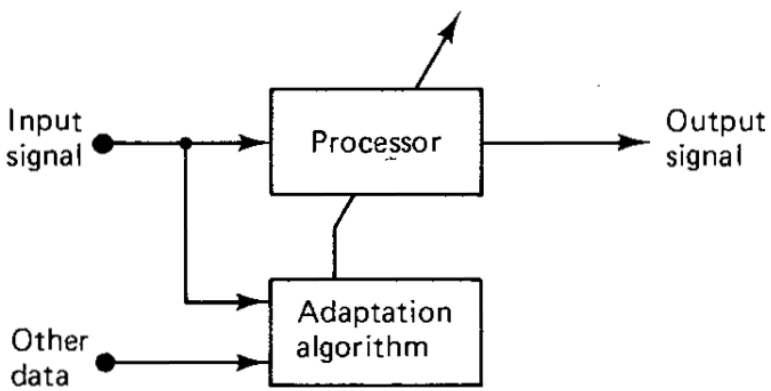
- **Final assessment** on January 21, 2021: 20%
  - Open book exam. 24 hour turn in time.
  - Needless to say, includes the entire syllabus.

Content

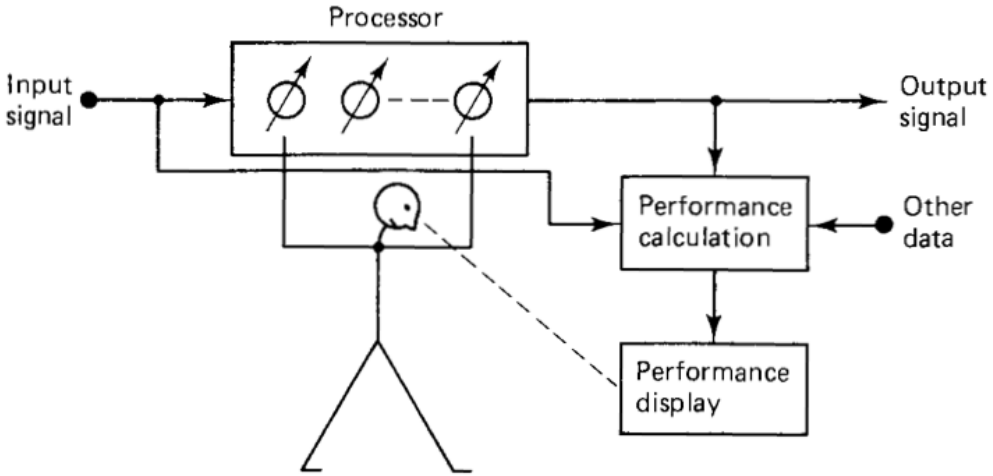
- Review of linear algebra and random processes.
- Optimal estimation.
- Linear estimation.
- Steepest-descent algorithms.
- Stochastic-gradient algorithms.
- Least squares and recursive least squares.
- Kalman filtering.
- Blind deconvolution and beamforming.
- Subspace tracking.
- Robust adaptive filters.
- Selected emerging topics
  - Graph signal processing.
  - Iterative solvers of large-scale linear systems.
  - Ill-posed inverse problems.

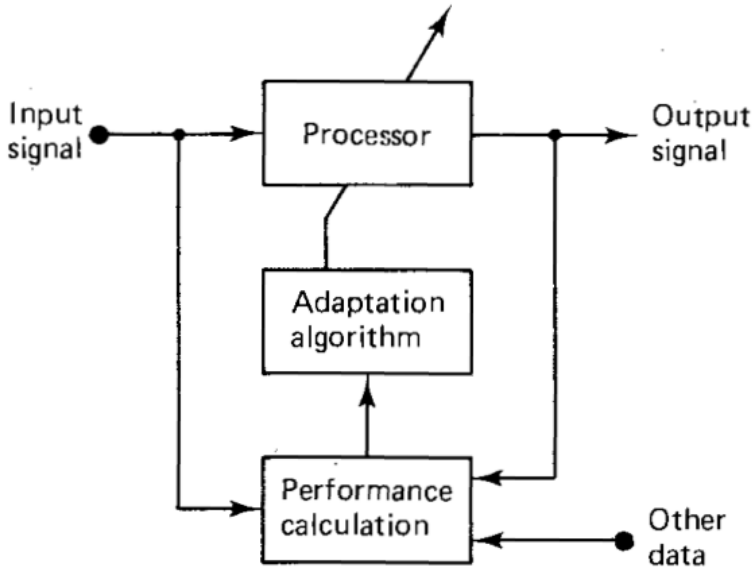
Open-loop adaptation





Closed-loop adaptation

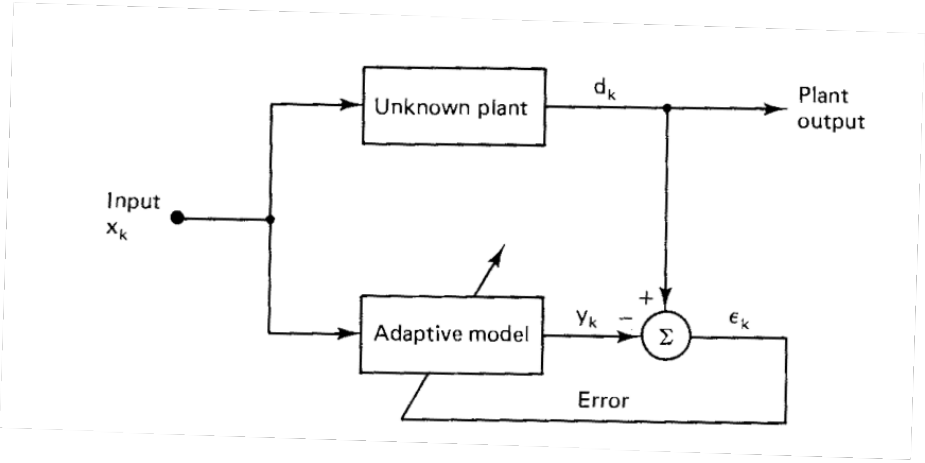


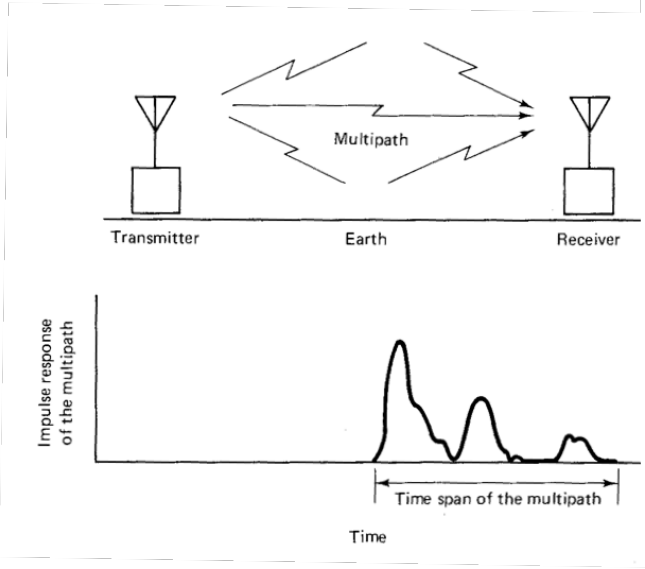


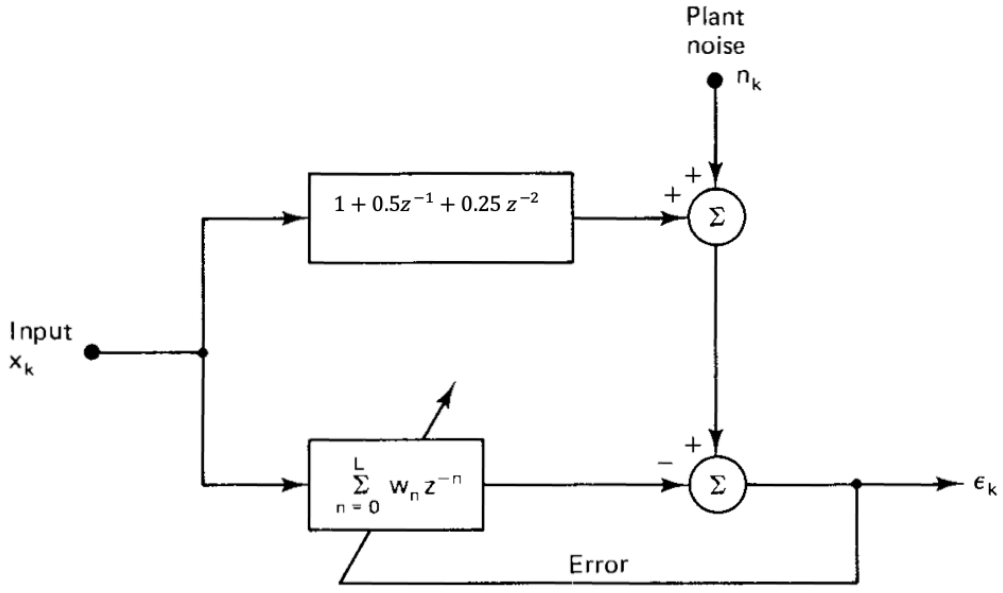
Applications

- Signal modeling and identification
- Inverse modeling, equalization, and deconvolution
- Prediction
- Interference cancellation

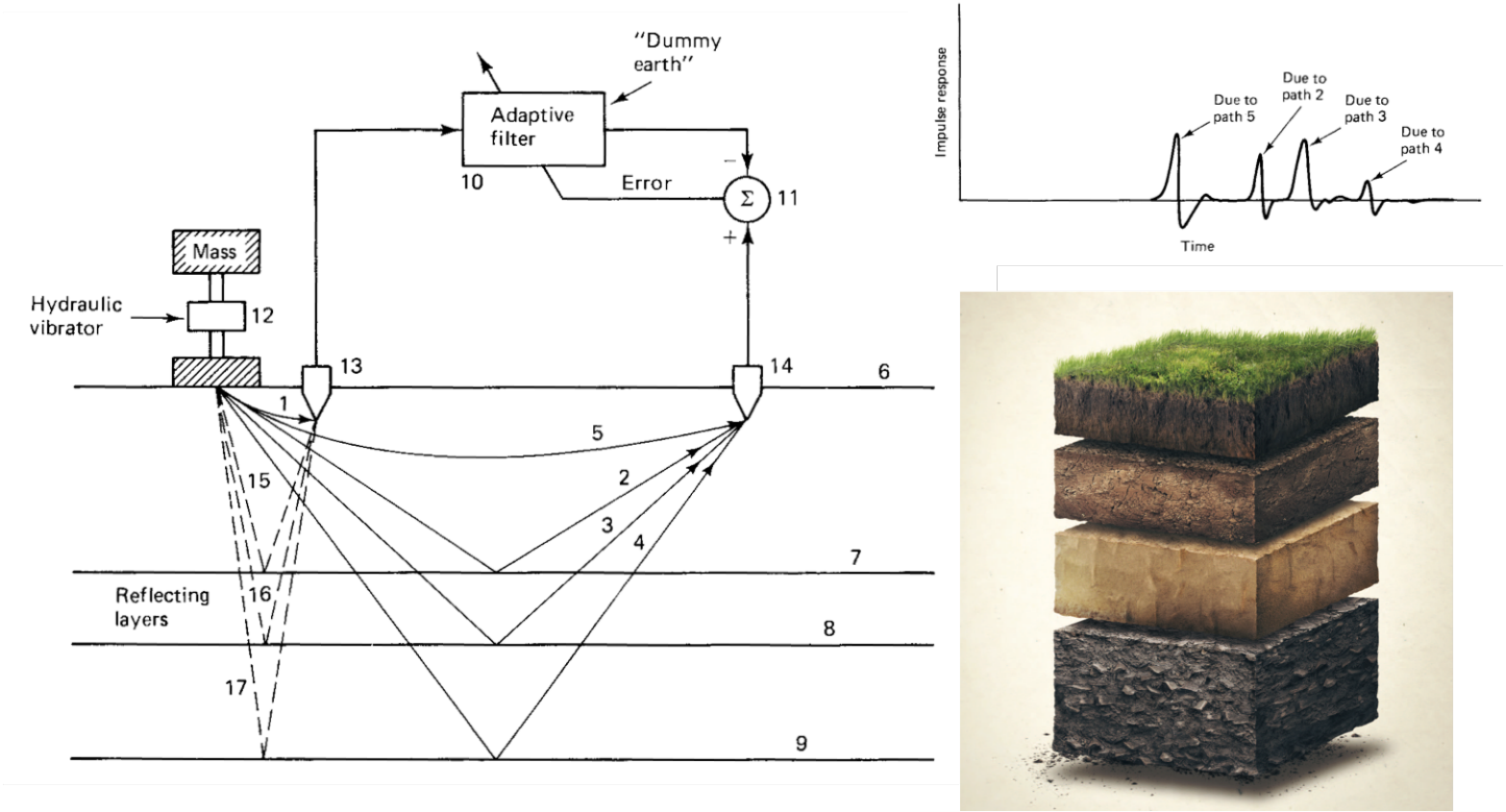
Signal modeling and identification





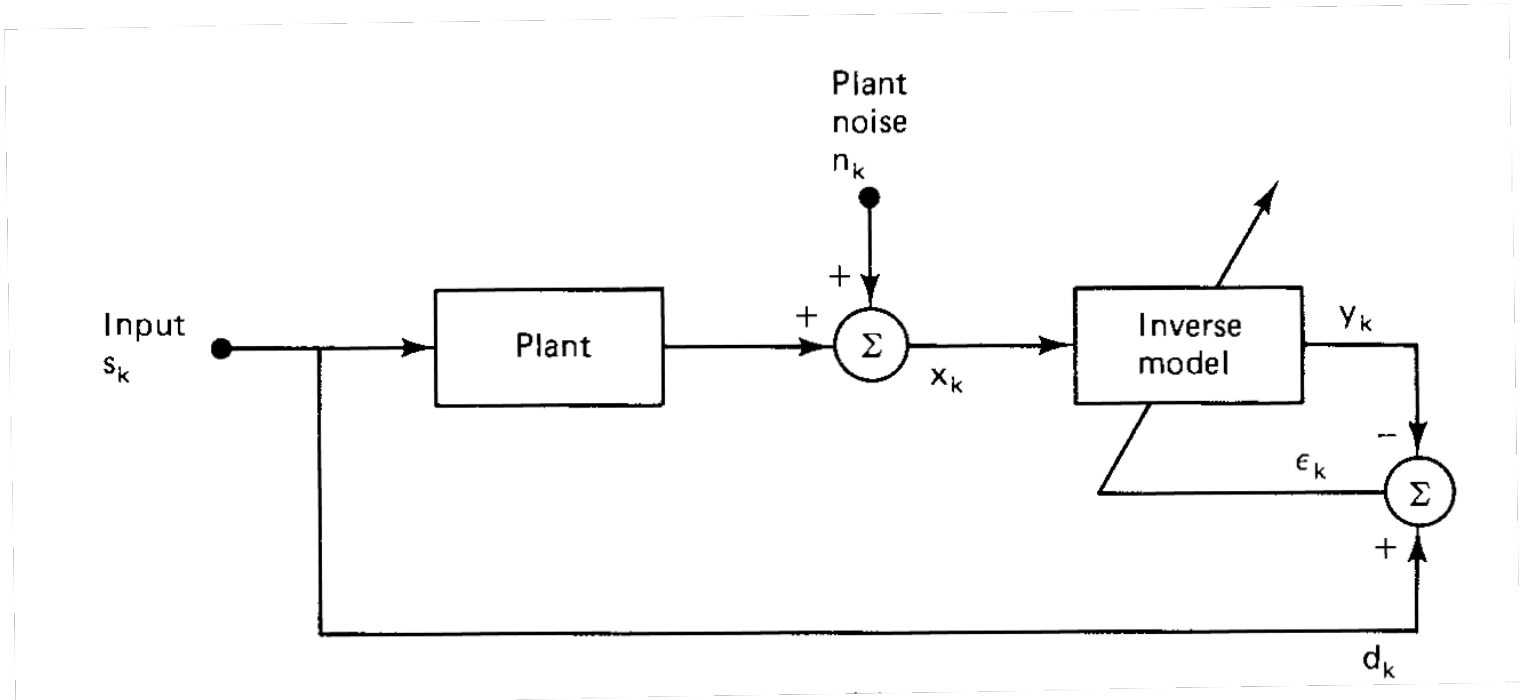


Signal modeling and identification



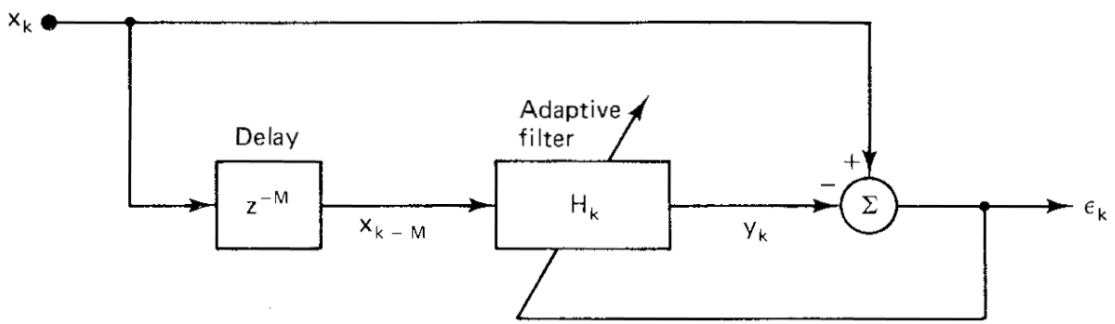
Seismic impulse response for subsurface imaging ("layer identification").

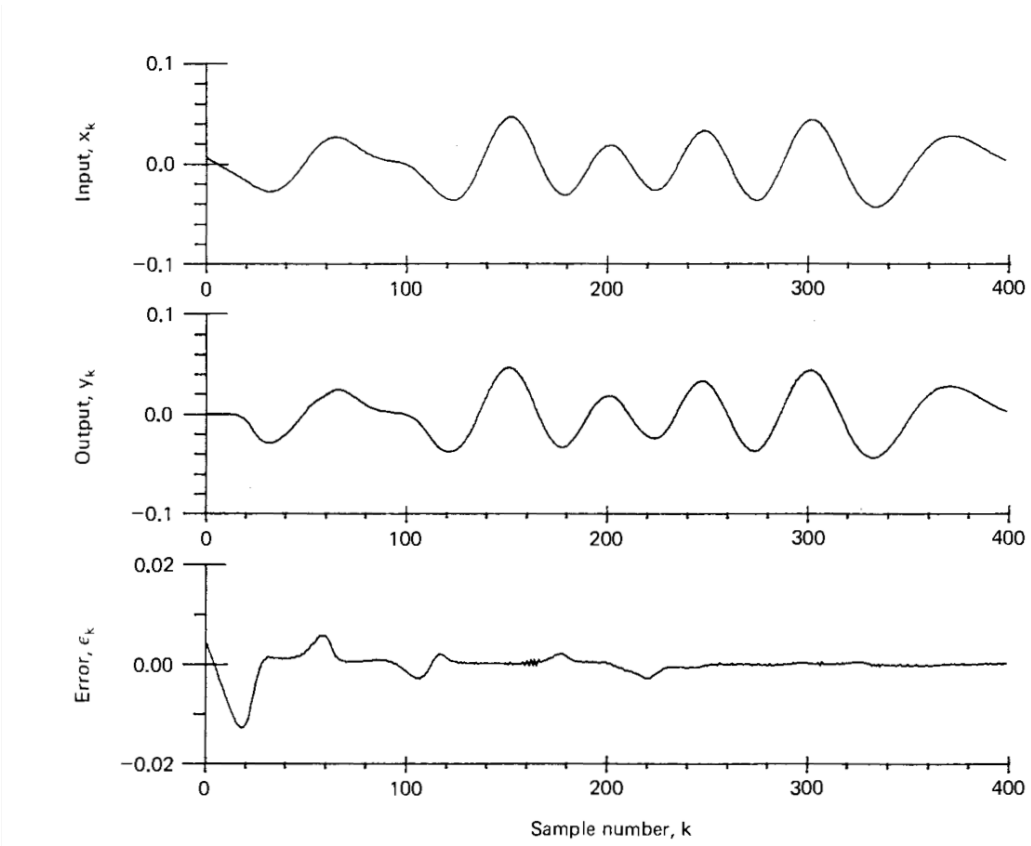
Inverse modeling, equalization, and deconvolution



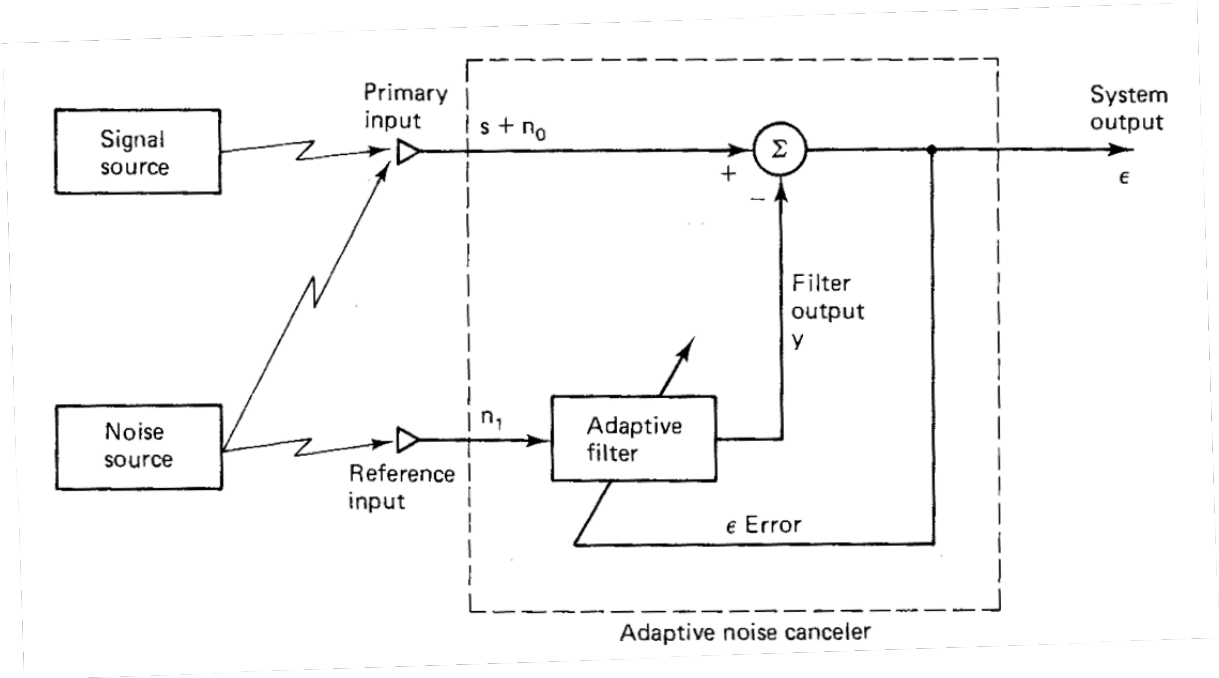
Example: channel equalization

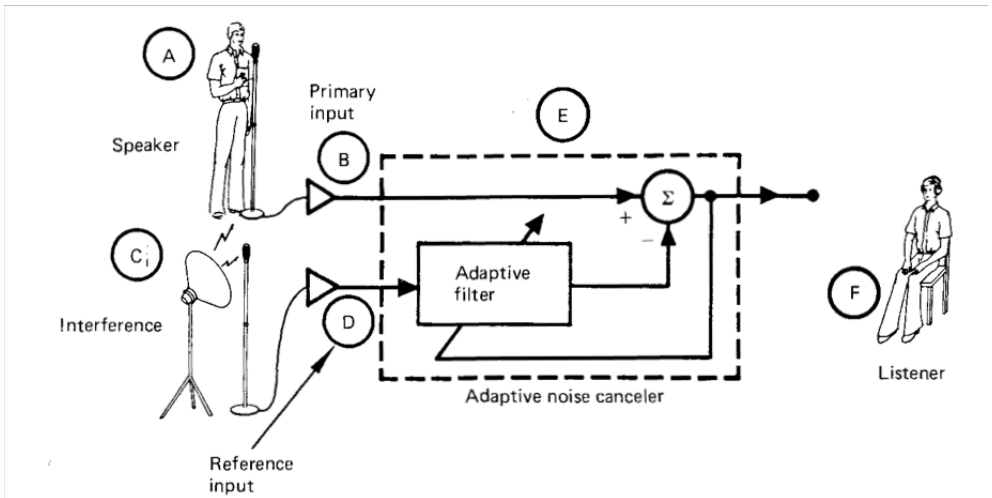
Prediction


x_k
Delay
z^{-M}
x_{k-M}
Adaptive filter
H_k
y_k
+
−
Σ
ϵ_k

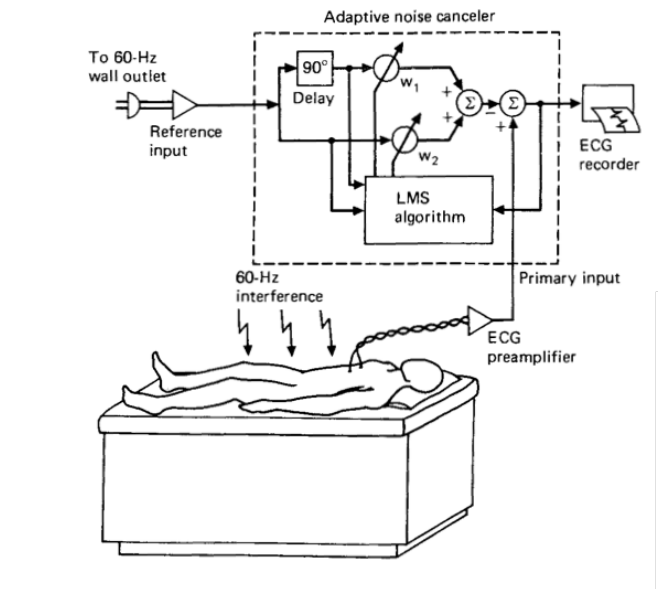

Input, x_k
0.1
0.0
−0.1
0
100
200
300
400
Output, y_k
0.1
0.0
−0.1
0
100
200
300
400
Error, ϵ_k
0.02
0.00
−0.02
0
100
200
300
400
Sample number, k

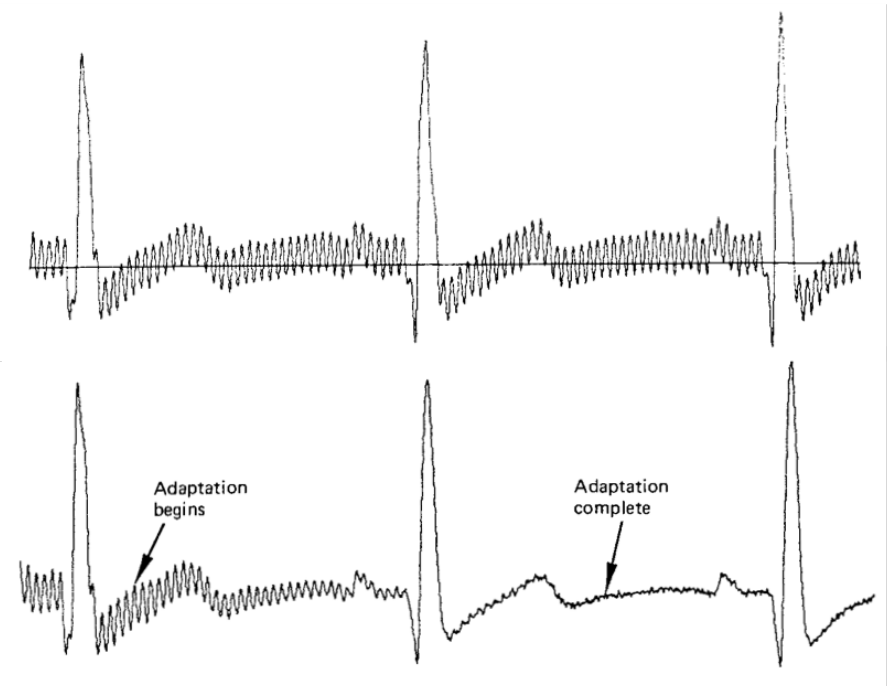
Interference cancellation

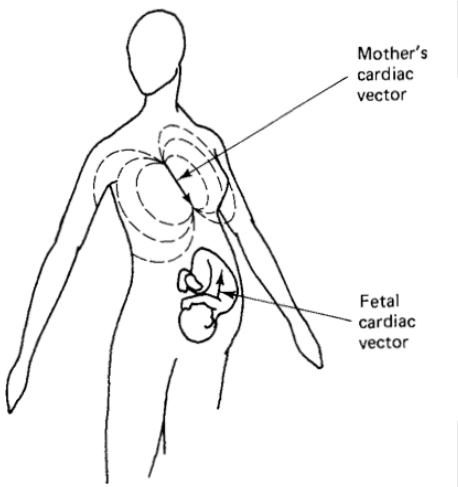


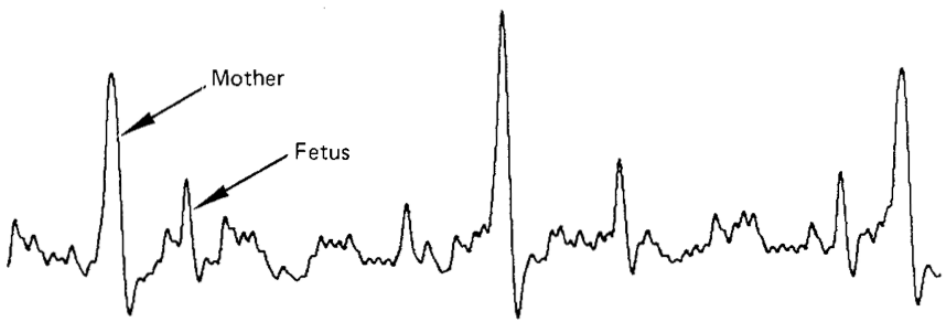


Interference cancellation

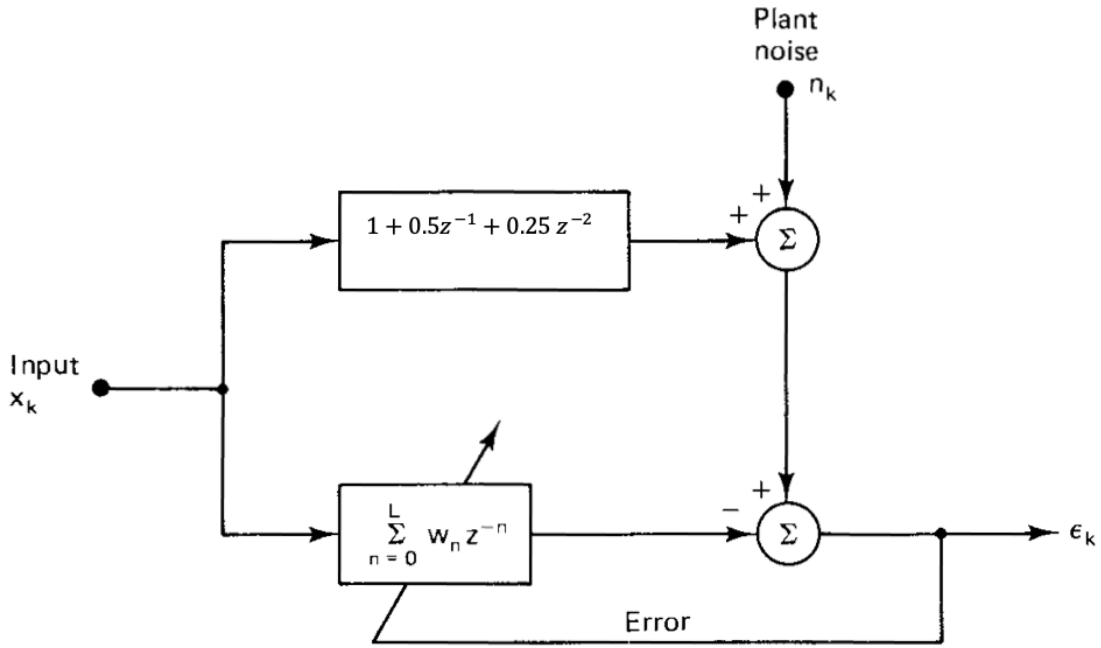








Course objectives



- How to **mathematically formulate** such problems?
- We use **optimization** techniques to compute filter weights. Are the filter weights that we compute **unique**?
- How to analyze the **performance** of the adaptive algorithms? Are these adaptive filters **stable**? Do they **converge** or diverge?