Adaptive Systems UE (442.012)
WS 19/20

Thomas Wilding

thomas.wilding@tugraz.at

Friday, 11.10.2019

Course Organization

Adaptive Systems UE (442.012)

- Problem class to accompany *Adaptive Systems VO* (442.011)
- Course website:
  - `https://www.spsc.tugraz.at/courses/adaptive-systems.html`
  - problem class handout (as pdf)
  - list of problem classes (and covered problems)
  - homework assignments (as pdf)
  - these slides
- Newsgroup: `tu-graz.lv.adaptive`
- TeachCenter: access via TUGRAZonline (you need to be registered for the course)

Course Organization

- **9 problem classes:** (in english)
  - problems from the handout calculated at the blackboard (by me)
  - attendance not mandatory but the problems will help with the homework assignments
  - you have to take your own notes
  - ask questions in class, in the newsgroup, ...
- **3 homework assignements: 30-35 points each, 100 points in total**
  - 3 problems
  - 1-2 bonus problem(s)

Course Organization

Homework Assignments: 30-35 points each

- analytical problems and Matlab/Octave problems
- you should (can) work in groups of max. 2 students (you can switch groups between assignments)
- $\sim$3 weeks per assignment, Q&A session $\sim$1 week before deadline
- hand in a hard copy of your analytical results
- send your Matlab/Octave files and simulation protocol by mail
- do not copy from other groups, do not hand assignments in late (-10 pts./day)
- overall: $\underline{100\,\text{pts.}}$ + bonus pts. + Latex bonus pts. (1 pt./assignment prob.)

achieved points	grade
≥ 88	1
$75 \ldots 87$	2
$62 \ldots 74$	3
$49 \ldots 61$	4
≤ 48	5

Literature

Books about adaptive filtering:

- "Adaptive Filter" by *G. Moschytz and M. Hofbauer* (in German only)
- "Adaptive Filter Theory" by *Simon Haykin*

Signal processing in general:

- "Foundations of Signal Processing," *M. Vetterli, J. Kovačević, and V. K. Goyal* (available for free online)

Before we start...

... a quick announcement

Presentation of Bachelor Theses, Master Theses and Master Projects at the SPSC

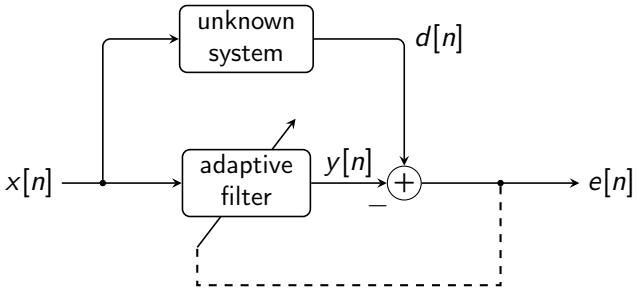
- Friday, 18.10.2019
- at 15:00
- in the SPSC Seminarroom (IDEG 134), ground floor, Inffeldgasse 16/c
- afterwards there will be pizza, beer and demos!

Introduction

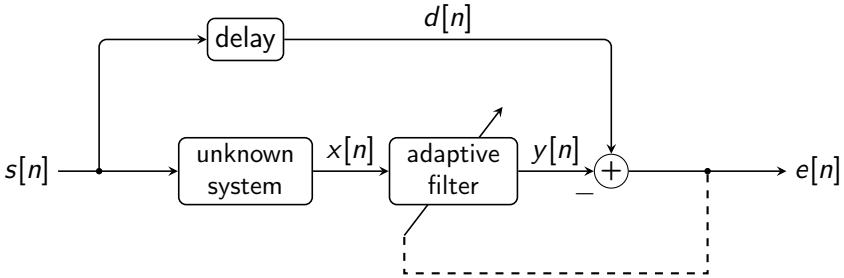
Topics/Chapters we will cover:

1. Least Squares Filtering and Wiener Filtering
2. *Least Mean Squares* (LMS) Algorithm
3. Interference Cancellation
4. Linear Prediction
5. Adaptive Equalization

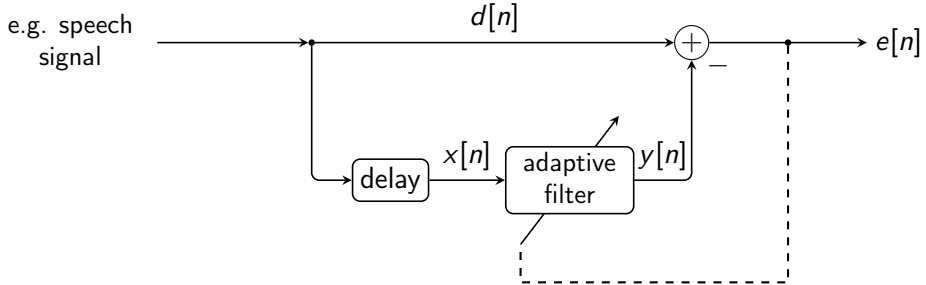
System Identification:



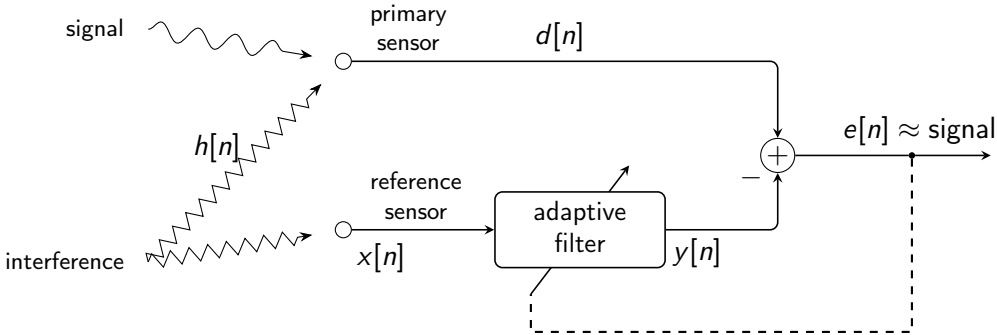
Inverse Modeling:



Linear Prediction:

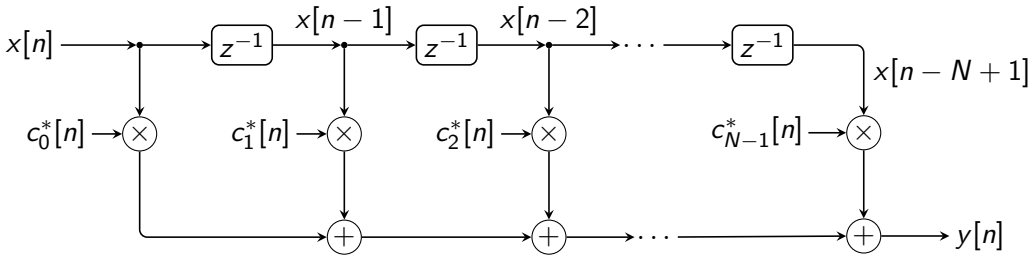


Adaptive Interference Canceler:



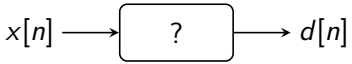
Optimum Linear Filtering

Adaptive FIR Filter: N coefficients and order $N-1$



Problem 1.1

The following input/output measurements performed on a black box are given:

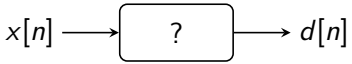


n	$x[n]$	$d[n]$
0	-1	-3
1	-1	-5
2	1	0

Find the optimum Least-Squares Filter with $N = 2$ coefficients. Use matrix/vector notation for the general solution. Note that the input signal $x[n]$ is applied to the system at time $n = 0$, i.e., $x[-1] = 0$.

Problem 1.1

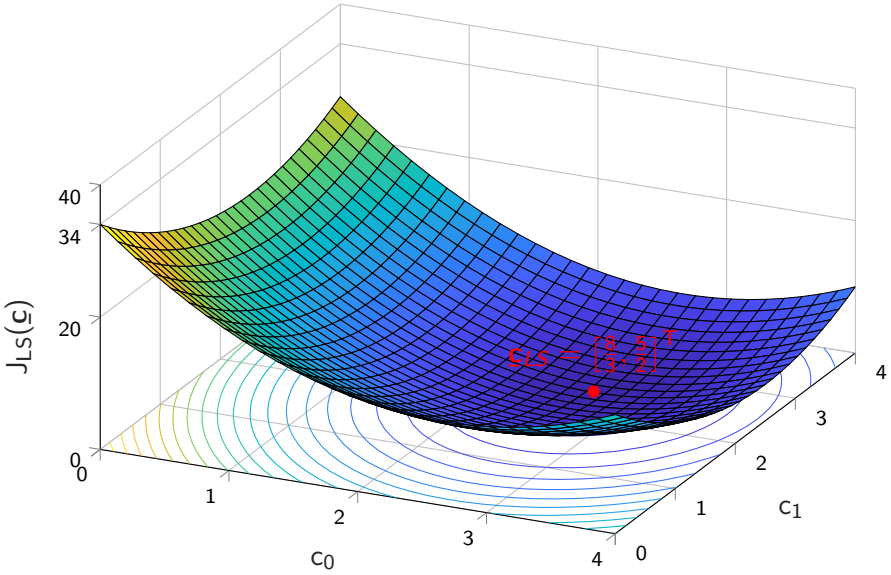
The following input/output measurements performed on a black box are given:



n	$x[n]$	$d[n]$
0	-1	-3
1	-1	-5
2	1	0

Find the optimum Least-Squares Filter with $N = 2$ coefficients. Use matrix/vector notation for the general solution. Note that the input signal $x[n]$ is applied to the system at time $n = 0$, i.e., $x[-1] = 0$.

Problem 1.1


40
34
20
0
$J_{LS}(\underline{c})$
0
1
2
3
4
c_0
0
1
2
3
4
c_1
$\underline{c}_{LS} = [2.5 \; 1]^T$

Problem 1.2.

The previous problem has demonstrated that gradient calculus is important. To practice this calculus, determine $\nabla_{\underline{\mathbf{c}}} J(\underline{\mathbf{c}})$ for the following cost functions:

(*i*) $J(\underline{\mathbf{c}}) = K$

(*ii*) $J(\underline{\mathbf{c}}) = \underline{\mathbf{c}}^{\mathsf{T}} \underline{\mathbf{v}} = \underline{\mathbf{v}}^{\mathsf{T}} \underline{\mathbf{c}} = \langle \underline{\mathbf{c}}, \underline{\mathbf{v}} \rangle$

(*iii*) $J(\underline{\mathbf{c}}) = \underline{\mathbf{c}}^{\mathsf{T}} \underline{\mathbf{c}} = ||\underline{\mathbf{c}}||^2 = \langle \underline{\mathbf{c}}, \underline{\mathbf{c}} \rangle$

(*iv*) $J(\underline{\mathbf{c}}) = \underline{\mathbf{c}}^{\mathsf{T}} \underline{\mathbf{A}} \underline{\mathbf{c}}$, where $\underline{\mathbf{A}}^{\mathsf{T}} = \underline{\mathbf{A}}$.

References

- **G. Moschytz and M. Hofbauer** (unfortunately in German only)
  "Adaptive Filter," *Springer Verlag*, Berlin Heidelberg, 2000
- **Simon Haykin**
  "Adaptive Filter Theory," Fourth Edition, *Prentice-Hall, Inc.*, Upper Saddle River, NJ, 2002
- **M. Vetterli, J. Kovačević, and V. K. Goyal**
  "Foundations of Signal Processing," Cambridge University Press, 2014.