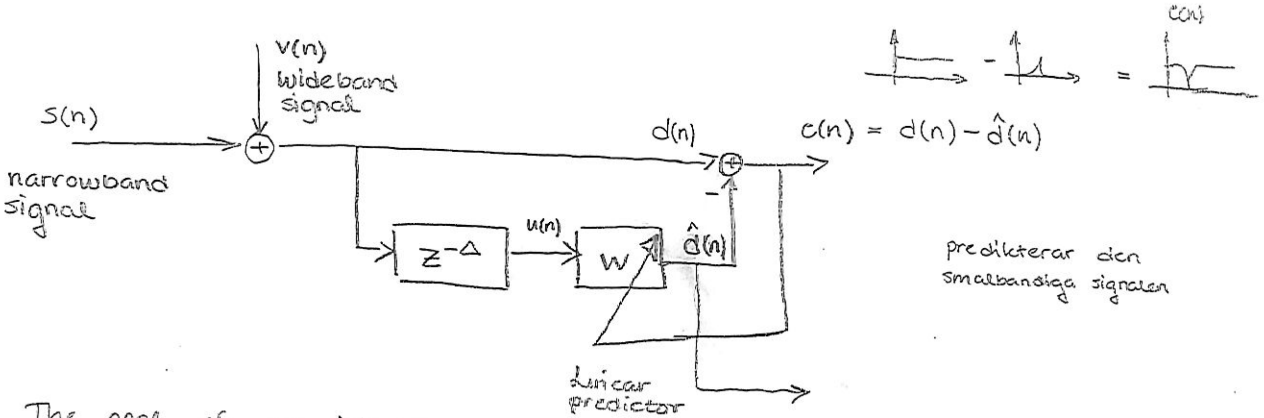
Lab 2

This lab deals with the Adaptive Line Enhancer. (ALE)



The goal of an Adaptive Line Enhancher is to supress the wideband noise component and passing through the narrowband signal.

Prep. 1

In the lab, d(n) to the ALE, is transmitted from the PC to the DSP. This transmission introduce additional noise and possibley 50 Hz from the power line. The question is. Why is it important to remove this 50 Hz distorsions? What difficulties would it introduce to the ALE?

We have to remove the 50 Hz distorsion in order to avoid that the ALE adapt to 50 Hz, instead of the frequency in the narrowband signal.

Prep. 2

The LMS algorithm converges when the stepsize μ is between

$$0 < \mu < \frac{2}{\lambda_{max}}$$

Explain why this is a reasonable approximation

$$0 < \mu < \frac{2}{\sum_{k=0}^{M-1} E[|u(n-k)|^2]}$$

$$R = Q^H \Lambda Q \qquad \Lambda = QRQ^T$$

$Q^TQ = I$ Q-unitary matrix $Q^T = Q^{-1}$

Eigenvalue decomposition of the correlation matrix R

Properties of the trace

$$0 < \mu < \frac{2}{\lambda_{max}} \quad \frac{2}{\sum_i \lambda_i} = \frac{2}{tr\Lambda} = \frac{2}{trR} = \frac{2}{Mr_u(0)} =$$

stricter limit

sum of the diagonal elements

$$= \frac{2}{\sum_{k=0}^{M-1} \underbrace{E[u^2(n-k)]}_{r_u(0)}} \approx \frac{2}{\sum_{k=0}^{M-1} u^2(n-k)}$$

approximation i LMS

In the lab $M = 100$ and $u(n)$ a signal with values between ± 1

Determine a stepsize μ_{max} which in any case assures a stable LMS.

Need to calculate $\sum_{k=0}^{M-1} E\{|u(n-k)|^2\}$ in the worst case, find its maximum.

Worst case is either $+1$ or -1.

$$\sum_{k=0}^{M-1} E\{|u(n-k)|^2\} = \sum_{k=0}^{M-1} 1 = M$$

$$\mu_{max} = \frac{2}{M} = \frac{2}{100} = 0.02$$

Prep. 3

In this assignment we are going to determine the eigenvalue spread. The eigenvalue spread has also an effect on the convergence of the LMS algorithm. Larger eigenvalue spread gives slower adaptation.

The task is to determine the eigenvalue spread $\chi = \frac{\lambda_{max}}{\lambda_{min}}$ of the correlationmatrix R_x for an AR(2)-process which is generated by

$$H(z) = \frac{1}{1 - a_1 z^{-1} + 0.95 z^{-2}}$$

for different a_1

i) $a_1 = 0.195$

ii) $a_1 = 0.975$

iii) $a_1 = 1.9114$

Go to next paper

The AR-process is characterized by

$$x(n) = a_1 x(n-1) + a_2 x(n-2) + v(n) \qquad \text{p. 213} \qquad (4.33)$$

$v(n)$ is white noise with zero mean and variance σ_v^2

$$r_x(k) = E[x(n)x(n-k)] =$$
$$= E[x(n)(a_1 x(n-1-k) + a_2 x(n-2-k) + v(n-k))] =$$
$$= a_1 r_x(k+1) + a_2 r_x(k+2) + \underbrace{E[x(n)v(n-k)]}_{=0 \quad k<0}$$

$r_x(k)$ är symmetrisk, men rekursionen gäller bara för $k<0$

Not correlated with future noise.

For $k=-1$ using the symmetry of the correlationfunction

$$r_x(-1) = r_x(1) = a_1 r_x(0) + a_2 r_x(1) \Rightarrow r_x(1) = \frac{a_1}{1-a_2} r_x(0)$$

$$R_x = \begin{bmatrix} r_x(0) & r_x(1) \\ r_x(1) & r_x(0) \end{bmatrix} = r_x(0) \begin{bmatrix} 1 & \frac{a_1}{1-a_2} \\ \frac{a_1}{1-a_2} & 1 \end{bmatrix}$$

The eigenvalues of R_x $\lambda = r_x(0)\left(1 \pm \frac{|a_1|}{1-a_2}\right)$, $r_x(0)$ will not influence the eigenvalue spread

$$\chi(R_x) = \frac{\lambda_{max}}{\lambda_{min}} = \frac{1 + \frac{|a_1|}{1-a_2}}{1 - \frac{|a_1|}{1-a_2}}$$

i) $\chi(R_x) \approx 1.22$

ii) $\chi(R_x) = 3$

iii) $\chi(R_x) \approx 100$

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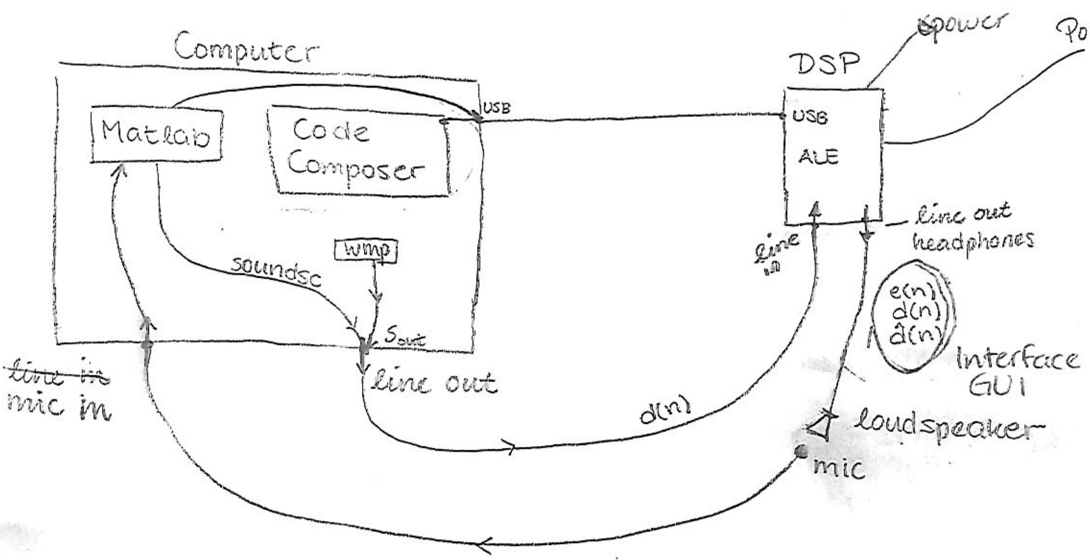
1) Investigate influence of stepsize, and eigenvalue spread
One of the assignments are to compare the LMS with the Leaky LMS. help lms 1 Suitable parameters.

The Leaky LMS has the advantage to hold back the coefficients. By this we are changing the costfunction and the solution will converge to another solution than the optimal coeff.

2)



play sound with soundsc WMP
look at the Spectrum with ai_fft
change parameters with InterfaceGUI

In the second part of the lab we will use a DSP.-board. Where a adaptive line enhancer is programmed, and we will investigate the performance of it.
Here is the set-up we are going to use.

(Code composer is very unstable
This program is very unstable! It will crash several times. Retry it. Follow the instructions carefully
and have patent with the computer.)

First you do: CCS
Debug → Connect

Skip 3.5