Signals, Systems and Modulations

Laboratory no. 3

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LABORATORY GROUP MEMBERS:

Jan Choraży

Krzysztof Watras

Computer Science

Politechnika Warszawska

Documentation of laboratory work results

Table 1: Improvement of SNR due to adaptive filtering

Adaptation speed	**SNR improvement**
0.001	1.0381
0.01	4.5035
0.1	9.3433
1	8.7925
10	-5.3501
20	NaN

Influence of the adaptation speed on denoising process.

Adaptation speed Beta describes the rate at which the filter coefficients are updated in response to changes in the input signal. If it is too high, the algorithm might "overshoot" the optimal values causing the filter to become unstable, leading to bad convergence and poor denoising performance. If the coefficient is too small however, the filter may not be able to track the changes in the signal quickly enough to converge efficiently or at all. This will also lead to poor results of denoising. In the case of Task1.1, the best adaptation speed is around 0.1.

Table 2: Improvement of SNR at different values of the input SNR

SNR input	**SNR improvement**
-5	9.4705
0	9.3433
5	8.9773
10	8.0079
20	2.4605

What happens if the adaptation speed is too high? And too low?

In this part, the improvement of SNR decreased when the value of SNR_{in} increased. The filter was most efficient when the initial SNR was negative (-5 dB) and least efficient for the highest initial SNR (20 dB). This proves the filter is able to significantly improve the signal even when it is heavily corrupted by noise – in the case of -5dB. When the initial SNR is much higher, the improvement is much smaller, possibly due to the fact the signal has less noise to begin with.

Best adaptation speed was found to be: 0.011

Table 3: Improvement of SNR due to adaptive filtering. Echo delay=0.5.

Adaptation speed	**SNR improvement**
0.001	4
0.01	7.6208
0.1	1.6521
0.05	3.7118
0.005	6.8659
0.007	7.3609
0.009	7.5828
0.011	7.6216
0.012	7.5918

In this experiment we changed the Echo/signal ratio and compared the improvements in SNR. For very low values of $SNR <= 0.01$ the improvement was negative, which means the filter has corrupted the noise further. When the values of the Echo/signal increased, so did the improvement of SNR until the Echo/signal ratio reached 0.5. For values greater than 0.5, the improvements of SNR started deteriorating – possibly due to the fact, that for the ratio bigger than 0.5 the amount of echo was greater than the amount of the original signal, causing the filter to adapt to the echo rather than the signal.

Table 4: The improvement of signal to echo ratio at different values of echo amplitude

Echo/signal ratio	**SNR improvement**
0.001	-39.5561
0.01	-19.5554
0.1	0.0034
0.2	4.7754
0.5	7.6216
0.6	7.5497
0.7	3.315
0.99	6.2976

Describe the influence of the adaptation speed on prediction gain.
A faster adaptation speed has significant influence on prediction gain in adaptive systems. Faster adaptation speed can lead to higher prediction gain, but too big can lead to unstable behaviour.

What is the difference between results obtained for speech signal and sine signal?
Because the speech signal is composed of multiple harmonics it is highly different from simple sine signal. In our experiments we found that the results obtained for the speech signals and sine signal differ in terms of the prediction gain and the stability of the predictor. For the speech signals, the prediction

Table 5: The influence of the adaptation speed on prediction gain

Echo/signal ratio	**Gain**
0.001	0.9433
0.01	4.8289
0.1	7.9827
1	9.2575
10	9.06
20	-1297.3

Table 6: The influence of the number of coefficients M

no. of prediction coefficients	**Gain**
1	7.3939
2	8.4688
5	8.6515
10	9.2575
20	10.2437
40	11.4998

Table 7: Test of the predictor of 1, 2 and 4 coefficients

Adaptation speed	**no. of prediction coefficients**	**Gain**
1	1	9.1454
5	1	8.8129
0.5	1	9.2334
0.1	1	9.3079
1	2	69.7873
5	2	66.1696
0.5	2	70.0464
0.1	2	68.2636
1	4	73.0399
5	4	60.5352
0.5	4	73.7804
0.1	4	74.3916

gain generally increases as the adaptation speed (step size) and the number of prediction coefficients increase, up to a certain point. Beyond that point, the predictor becomes unstable and the prediction gain decreases drastically. This behavior is due to the non-stationary nature of speech signals, which makes it difficult to accurately model the signal using a linear predictor. On the other hand, for the sine signal, the prediction gain generally increases as the adaptation speed and the number of prediction coefficients increase, without any sign of instability. This behavior is due to the stationary nature of the sine signal, which makes it easier to accurately model the signal using a linear predictor. Therefore, the speech signals are generally more challenging to predict accurately than stationary signals like the sine signal, and require careful selection of the adaptation speed and number of prediction coefficients to achieve good prediction performance.