

SGN-4010 Puheen käsittelyn Menetelmät

Speech Processing Methods

Exam 29.1.2009

You may answer either in Finnish or English.

Problem 1. Explain briefly what the following terms mean (1 point/term): **a)** formant frequency, **b)** formant bandwidth (*formantin kaistanleveys*), **c)** International Phonetic Alphabet (IPA), **d)** glottis, **e)** vowel diagram (*vokaalidiagrammi*), **f)** prosody (*prosodia*).

Problem 2.

The samples $s(k)$ of a short frame of speech are

k	0	1	2	3	4	5	6
$s(k)$	1	2	1	-3	-1	0	1

- What is the autocorrelation function for this frame? (1 point)
- What are the 2nd-order LPC coefficients a_0, a_1, a_2 of the LPC polynomial $a_0 + a_1z^{-1} + a_2z^{-2}$? (1 point)
- What are the reflection coefficients (*heijastuskertoimet*) k_1, k_2 ? (2 points)
- What are two interpretations (*kaksi tulkintaa*) of the filtered signal $S(z)A(z)$, where $S(z)$ is the z -transform of the speech frame? (2 points)

Problem 3.

a) What 3 properties are used to classify how vowels are produced (*minkä kolmen ominaisuuden perusteella vokaalit luokitellaan*)? Explain each one in a few words. (3 points)

b) What 3 properties are used to classify how consonants are produced (*sama kysymys konsonanteille*)? (3 points)

Problem 4.

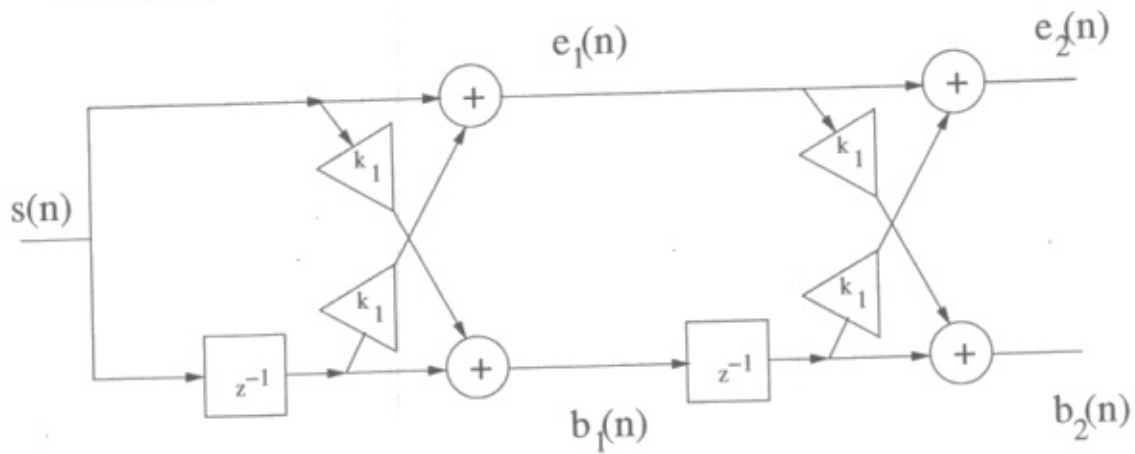
A lattice filter is shown in Fig. 1. The reflection coefficients are $k_1 = 0.9, k_2 = 0.5$ and they have been calculated to minimize the prediction error (*ennustusvirhe*) energy from the input speech $s(n)$ to the output $e_2(n)$.

a) What is the transfer function (*siirtofunktio*) of the filter from $s(n)$ to $e_1(n)$, $b_1(n)$ and $e_2(n)$? (2 points)

b) Given that the prediction error is given by $e_2(n)$, what is the all-pole-model of the vocal tract for this frame? (2 points)

c) What is the optimal 1st-order predictor for the speech frame? That is, what are the coefficients b_0 and b_1 such that if we predict $s(n+1)$ by $b_0s(n) + b_1s(n-1)$ over the speech frame, the prediction error is minimized?

d) Given that the autocorrelation $r(0)$ at lag 0 is 1, what are $r(1)$ and $r(2)$? (bonus point)



Kuvio 1: Lattice filter.