Chair of Computer Science 6
RWTH Aachen University
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Digital Processing of Speech and Image Signals

8. Exercise

Submission of the solutions: 18. 12. 2006 at the beginning of the lecture

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Task 8.1 Consider a signal $x[n]$ of length $N = 12$.

(a) Describe an efficient algorithm that computes the Discrete Fourier Transform of length $N = 12$ (i.e. without using zero-padding). (1 P.)

(b) What permutation is necessary so that the algorithm produces the correct order of the Fourier Transform coefficients? (1 P.)

(c) Give the exact complexity of the algorithm in terms of the number of additions. (1 P.)

(d) Describe the algorithm as a matrix product $X = T_s \cdot T_1 \cdot T_2 \cdot T_3 \cdot x$. (3 P.)

Task 8.2

The file `speech.dat` (available on the website of the lecture) contains a speech signal sampled at $f_S = 8$kHz. Produce a spectrogram for the signal with Octave (or Matlab):

a) To prepare the application of a window function, determine how many samples (n_{shift}, n_{window}) do the time values $t_{shift} = 10$ms and $t_{window} = 25$ms correspond to? (1 P.)

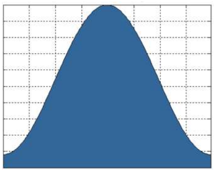
b) Load and plot the speech signal stored in the ASCII data `speech.dat`. (2 P.)

c) Compute a matrix which contains 250 segments (time frames) of the signal windowed by Hamming function. Time frames are to be produced with a distance of n_{shift} and with a length of n_{window}. Hint: look up the command `hamming(N)`. (2 P.)

d) Calculate the Fourier transform for each time frame and plot the matrix of amplitude spectra on a logarithmic scale. Hint: look up the commands `imshow` and `ocean`. (2 P.)

e) How can you recognize voiced and unvoiced sounds? Mark one voiced and one unvoiced sound on the spectrogram. (1 P.)

Hint: you can convert the file `speech.raw` under Linux to a `.wav` by the command `sox -x -t raw -r 8000 -s -w -c 1 speech.raw speech.wav` (`-x` reverse the byte order, `-t raw` file format is raw without header, `-r 8000` sampling rate in Hz, `-s -w` width of a sample is 16–bit (word)), `-c 1` use one channel).



Richard Wesley Hamming (1915 - 1998) was a mathematician whose work had many implications for computer science and telecommunications. His contributions include the Hamming code (which makes use of a Hamming matrix), the Hamming window, Hamming numbers, Sphere-packing (or hamming bound) and the Hamming distance.
He was a professor at the University of Louisville during World War II, and left to work on the Manhattan Project in 1945, programming one of the earliest electronic digital computers to calculate the solution to equations provided by the project's physicists. The objective of the program was to discover if the detonation of an atomic bomb would ignite the atmosphere. The result of the computation was that this would not occur, and so the United States used the bomb, first in a test in New Mexico, and then twice against Japan.
In one of the quotes accredited to him, he said *Machines should work. People should think.*
Source: `http://www.wikipedia.com`