5-min knowledge sharing/discussion

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Lab VIIII
Digital Coding of Speech Signals
– part 1

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Purpose of this lab...

1. Test and understand the statistical model of speech signal
2. Test and understand the process of uniform quantization

Problem 1

11.24. (MATLAB Exercise) The goal of this MATLAB exercise is to verify some aspects of the statistical model of speech, as discussed in Section 11.3. In this exercise you will use three concatenated speech files with the following content:

1. `out_s1_s6.wav`—the concatenation of six individual speech files (with beginning and ending silence regions removed), namely `s1.wav, s2.wav, s3.wav, s4.wav, s5.wav, s6.wav`
2. `out_male.wav`—the concatenation of four individual male speech files (with beginning and ending silence regions removed), namely `s2.wav, s4.wav, s5.wav, s6.wav`
3. `out_female.wav`—the concatenation of two individual female speech files (with beginning and ending silence regions removed), namely `s1.wav, s3.wav`

(a) Treating the large speech file as a source of statistical speech samples, determine the mean and variance of the speech signal, along with the minimum and maximum values. Create an amplitude histogram (using the MATLAB `hist` routine), and plot the histogram of the speech amplitudes using 25 bins for the histogram. Experiment with other numbers of bins for the histogram.

hist(x,nbins) or histogram(X,nbins)

(b) Using the m-file `pspect.m` from the book website, compute an estimate of the long-term average power spectrum of speech using the signal in the long concatenated file `out_s1_s6.wav`. Experiment with a range of window durations (e.g., 32/64/128/256/512) to determine the effect of window size on the smoothness of the power spectrum. Plot the power spectrum (in dB units, labeling the frequency axis appropriately), for the five window durations given above, on a common plot.

(d) Repeat part (b) for the window duration of 32 samples using both the male speech file (`out_male.wav`) and the female speech file (`out_female.wav`). Plot both power spectrums (again in dB units) on a single plot. How do the power spectrums for male and female speech compare?

Problem 2

11.25. (MATLAB Exercise) The goal of this MATLAB exercise is to experiment with the process of uniform quantization of a speech signal. This exercise uses the MATLAB function

```
X=fxquant(s,bits,rmode,lmode)
```

where

- `s` is the input speech signal (to be quantized)
- `bits` is the total number of bits (including the sign bit) of the quantizer
- `rmode` is the quantization mode, where `rmode` is one of `'round'` for rounding to the nearest level, `'trunc'` for 2's complement truncation, or `'magn'` for magnitude truncation
- `lmode` is the overflow/underflow handler, where `lmode` is one of `'sat'` for a saturation limiter, `'overfl'` for a 2's complement overflow, `'triangle'` for a triangle limiter, and `'none'` for no limiter
- `X` is the output (quantized) speech signal

(a) Create a linearly increasing input vector going from -1 to $+1$ in increments of 0.001, i.e., `xin=-1:0.001:1`, and use the MATLAB function `fxquant` to plot the non-linear quantizer characteristic for the conditions `bits=4, rmode='round', lmode='sat'`. Repeat this calculation and plot for the case of `rmode='trunc'`. What is the range of values for $e[n]$ when truncation is used instead of rounding?

(b) Use `fxquant( )` to quantize the speech samples of the file `s5.wav`, between sample 1300 and sample 18,800 (the speech file is exactly zero outside this range), with parameters:

`rmode='round', lmode='sat'.`

Experiment with different numbers of bits for the quantizer, namely 10 bits, 8 bits, and 4 bits. For each of these quantizers, compute the quantization error sequences and use the function strips (x, sd, fs) to plot the first 8000 of these error sequences with 2000 samples per line. What are the important differences between the error plots as a function of the number of bits in the quantizer? Make histograms of the quantization noise samples for each of these bit rates. Do the histograms look like they fit the white noise model (i.e., with a uniform amplitude distribution)?

(c) Compute the power spectrum of the quantization noise sequences for each of the quantizers of part (b) using the file `pspect( )`. Plot these spectra on the same plot as the power spectrum of the original (unquantized) speech samples. Do the noise spectra support the white noise assumption? What is the approximate difference (in dB) between the noise spectra for 10- and 8-bit quantization?