10-min knowledge sharing/discussion

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Speech Signal Processing

LAB IV

Time-Domain Methods for Speech Processing

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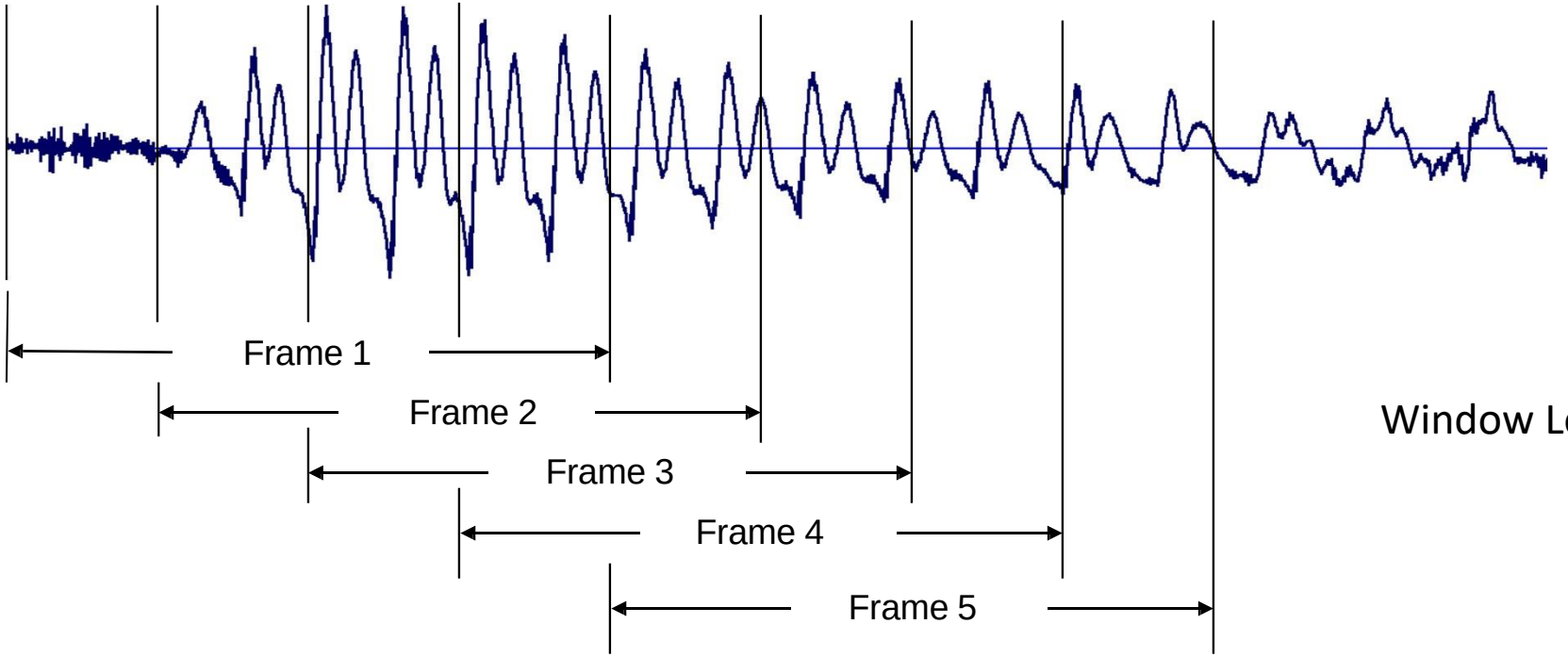
Purpose of this lab...

1. Learn the windowing effect for short-time speech analysis
2. Learn to analyse speech signal with short-time energy, magnitude and zero-crossing

Short Time Processing



Window Length: L

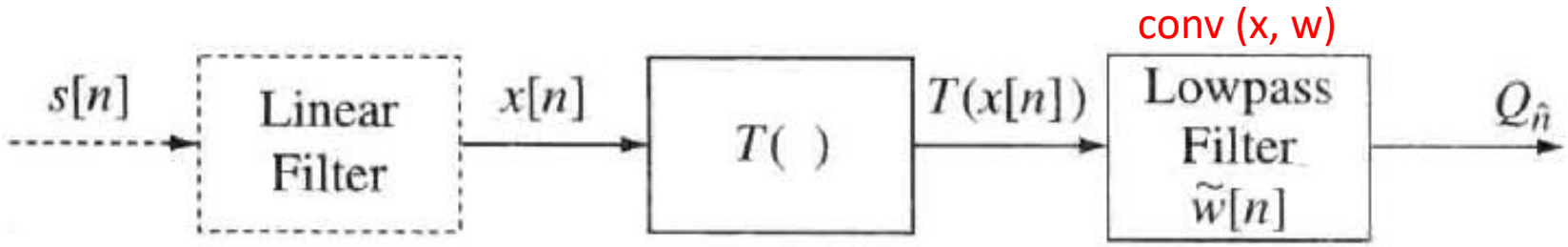
Frame1={x[0],x[1],…,x[L-1]}
Frame2={x[R],x[R+1],…,x[R+L-1]}
Frame3={x[2R],x[2R+1],…,x[2R+L-1]}
…

$$Q_{\hat{n}} = \sum_{n} T(x[n + \hat{n}R]w[n])$$

$$= \sum_{n} T(x[n]w[n - \hat{n}R])$$

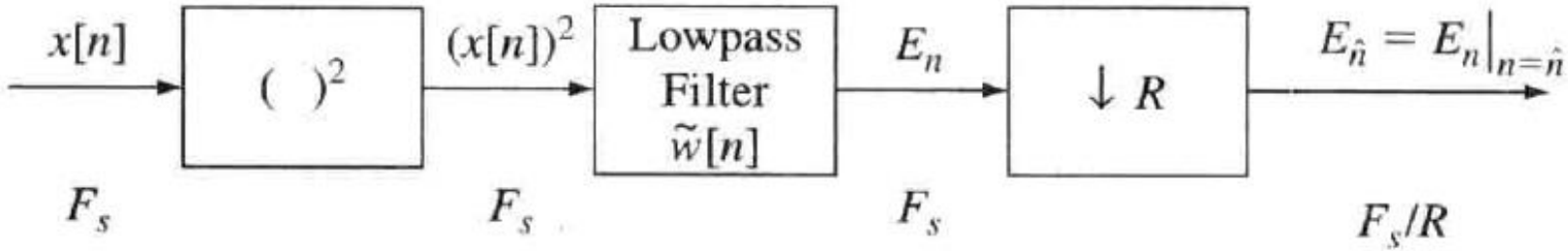
Short Time Processing

- General representation of short-time analysis principle



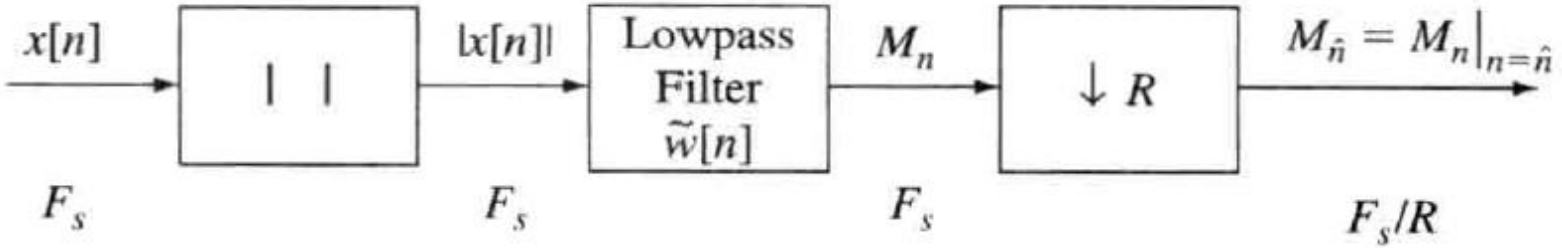
$$Q_{\hat{n}} = \sum_{n} T(x[n])\tilde{w}[\hat{n}R - n]$$

- Short-time energy

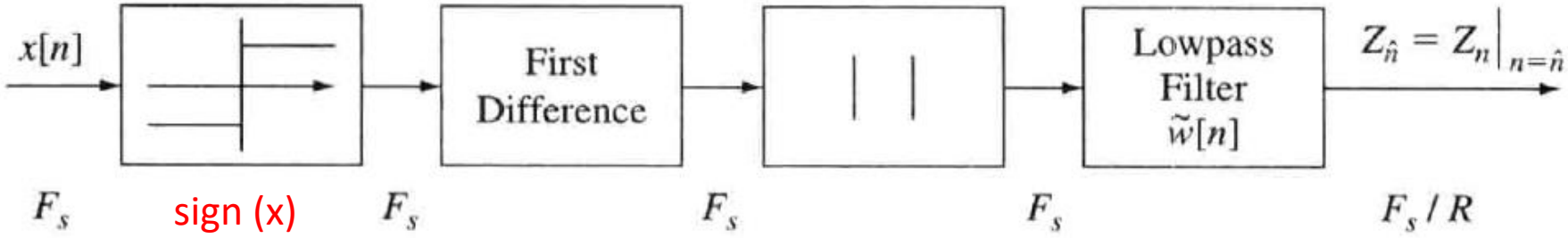


Short Time Processing

- Short-time magnitude



- Short-time zero-crossings



Problem 1

6.16. (MATLAB Exercise) Write a MATLAB program to plot (and compare) the time and frequency responses of five different L-point windows, namely:

1. Rectangular window: w = rectwin(L)

$$w[n] = \begin{cases} 1 & 0 \le n \le L-1 \\ 0 & \text{otherwise.} \end{cases}$$

2. Triangular window: w = triang (L)

$$w[n] = \begin{cases} 2n/(L-1) & 0 \le n \le (L-1)/2 \\ 2 - 2n/(L-1) & (L+1)/2 \le n \le L-1 \\ 0 & \text{otherwise.} \end{cases}$$

3. Hann window: w = hann (L)

$$w[n] = \begin{cases} 0.5 - 0.5\cos\left(\dfrac{2\pi n}{L-1}\right) & 0 \le n \le L-1 \\ 0 & \text{otherwise.} \end{cases}$$

4. Hamming window: w = hamming (L)

$$w[n] = \begin{cases} 0.54 - 0.46\cos\left(\dfrac{2\pi n}{L-1}\right) & 0 \le n \le L-1 \\ 0 & \text{otherwise.} \end{cases}$$

5. Blackman window: w = blackman (L)

$$w[n] = \begin{cases} 0.42 - 0.5\cos\left(\dfrac{2\pi n}{L-1}\right) + 0.08\cos\left(\dfrac{4\pi n}{L-1}\right) & 0 \le n \le L-1 \\ 0 & \text{otherwise.} \end{cases}$$

L = 101

Accept as input the value of the window duration, L, and check that it is an odd integer. Design the five windows and plot their time responses on a common plot. On a separate plot, show the log magnitude responses of all five windows. Compare the effective bandwidths of the five windows along with the peak sidelobe ripple (in dB). (Hint: You may want to consider replotting the log magnitude response over a narrow band between 0 and $5 * F_s/L$ to compare the effective bandwidths of the five windows.)

zero-padding

Problem 2

6.17. (MATLAB Exercise) Write a MATLAB program to analyze a speech file and simultaneously, on one page, plot the following measurements:

1. the entire speech waveform
2. the short-time energy, $E_{\hat{n}}$
3. the short-time magnitude, $M_{\hat{n}}$
4. the short-time zero-crossing, $Z_{\hat{n}}$

Use the speech waveforms in the files `s5.wav` [redacted] to test your program. Choose appropriate window sizes (L), window shifts (R), and window type (Hamming, rectangular) for the analysis. Explain your choice of these parameters. (Don't forget to normalize the frequency scale of your analysis depending on the sampling rate of the speech signal in each file.)

altrep = fun_name (audiomatrix, fs, R, win)

rectwin(L), hann(L) …

Problem 3

6.18. (MATLAB Exercise) Write a MATLAB program to show the effects of window duration on the short-time analysis of energy, magnitude, and zero-crossings. Using the speech file `test_16k.wav`, compute the short-time energy, magnitude, and zero-crossings using frame lengths of $L = 51, 101, 201, 401$ samples using either a Hamming window or a rectangular window. Plot the resulting short-time estimates on a common plot. What effects do you see as the window length shortens or lengthens?