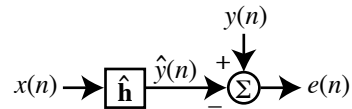


EE442 / EE592 Real-Time Digital Signal Processing
Quiz #3

Allowed: Textbook, Calculator only
(no data book, handouts, notes, etc...)

Each question is worth 10 points unless otherwise noted.

1. Consider the filtering configuration



and the MSE cost function

$$\xi = E[e[n]^2].$$

The solution to minimizing the cost function is the Wiener filter

$$\hat{\mathbf{h}} = \mathbf{R}^{-1}\mathbf{p}. \quad (1)$$

The solution can also be obtained iteratively with the steepest-descent algorithm

$$\hat{\mathbf{h}}[n+1] = \hat{\mathbf{h}}[n] + \mu(\mathbf{p} - \mathbf{R}\hat{\mathbf{h}}[n]) \quad (2)$$

with an appropriate μ . From an *implementation standpoint* (code complexity, code size, execution time, filtering quality, etc.) what are the pros and cons of computing the solution with (1) versus (2)?

Wiener filter

Pros

Cons

Steepest Descent

Pros

Cons

Write a code for the following *non-real-time* programming tasks (Questions 2 – 4). The first is done as an example.

2. Compute the following inner product

$$\begin{aligned} y &= \mathbf{h}^T \mathbf{x} \\ &= [0.4 \quad 0.3] \begin{bmatrix} 0.2 \\ 0.1 \end{bmatrix} \end{aligned}$$

Solution:

```
org    p:$100
move  #0.4,x0      ;x0 = 0.4
mpy   #0.2,x0,a    ;a = 0.4*0.2
move  #0.1,x0      ;x0 = 0.1
mac   #0.3,x0,a    ;a = 0.4*0.2 + 0.3*0.1 (ANSWER IN a)
```

3. Using the following arrays which have been allocated and loaded into memory

```
org x:$0
H_1   dc 0.6, 0.4      ;column 1 of H
x_1   dc 0.2           ;element 1 of x
y_1   ds 1             ;element 1 of y
org y:$0
H_2   dc 0.5, 0.3      ;column 2 of H
x_2   dc 0.1           ;element 2 of x
y_2   ds 1             ;element 2 of y
```

compute the following matrix multiply:

$$\begin{aligned} \mathbf{y} &= \mathbf{Hx} \\ &= \begin{bmatrix} 0.6 & 0.5 \\ 0.4 & 0.3 \end{bmatrix} \begin{bmatrix} 0.2 \\ 0.1 \end{bmatrix} \\ &= \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} \end{aligned}$$

Be sure that the resulting answers y_1, y_2 are stored at addresses y_1, y_2 , respectively. If you are unsure how to multiply matrices, please ask instructor for assistance.

4. Using the following arrays which have been allocated and loaded into memory

```
mu    equ    0.3
      org x:$0
h_vec dc 0.5, 0.4
y_vec ds 2
      org y:$0
x_vec dc 0.2, 0.1
```

compute the following linear combination of vectors

$$\begin{aligned} \mathbf{y} &= \mathbf{h} + \mu \mathbf{x} \\ &= \begin{bmatrix} 0.5 \\ 0.4 \end{bmatrix} + 0.3 \begin{bmatrix} 0.2 \\ 0.1 \end{bmatrix} \\ &= \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} \end{aligned}$$

Be sure that the resulting answers y_1, y_2 are stored at addresses y_vec, y_vec+1 , respectively.

Write a code for the following programming tasks (Questions 5 - 7), assuming the Modified Pass Pack beginning on p. 321 of the text. Identify by file name (**pass.asm**, **pass.dat**, **proginit.asm**, and **procster.asm**) and line number where you would place your instructions. The first programming task is done as an example.

5. Write a code which multiplies the right channel by $g = 0.7$.

Solution:

In **pass.dat** insert after line 10 the following line:

```
g    equ    0.7
```

In **procster.asm** replace the NOP the following line:

```
mpyr  #g,x0,a    ;multiply right sample by g and round
```

In **pass.asm** replace line 75 with the following line:

```
move  a,x:TX_BUFF_BASE    ;transmit right sample
```

6. Write a code which computes the energy of the most recent 100 input samples (right channel)

$$\|\mathbf{x}[n]\|^2 = \sum_{k=0}^{99} x[n-k]^2$$

and stores the value in accumulator a. Your code should simply implement the iteration

$$\|\mathbf{x}[n]\|^2 = \|\mathbf{x}[n-1]\|^2 + x[n]^2 - x[n-100]^2.$$

7. Equations (5.12) – (5.14) on p. 172 of the textbook give the state equations for the all-pass filter. Write a code which implements right channel filtering assuming all-pass filter parameters, $g = 0.7$ and $m = 307$.

EE592 Only

8. Consider the ALE example on p. 209 but where $N = 48$, $L = 64$, $\tilde{\mu} = 0.5$, and $a = 10^{-2}$. For the following energy and error values, determine which case (#1, #2a, #2b) and the resulting value for $\mu(n)$

(a) $\mathbf{x}[n]^T \mathbf{x}[n] = 5.0$, $e[n] = -0.5$

Case # _____ $\mu(n) =$ _____

(b) $\mathbf{x}[n]^T \mathbf{x}[n] = 0.005$, $e[n] = 0.5$

Case # _____ $\mu(n) =$ _____

(c) $\mathbf{x}[n]^T \mathbf{x}[n] = 0.5$, $e[n] = 0.005$

Case # _____ $\mu(n) =$ _____

(d) $\mathbf{x}[n]^T \mathbf{x}[n] = 0.005$, $e[n] = 0.005$

Case # _____ $\mu(n) =$ _____