EE.5351 Digital Video Coding

Instructor: K.R.Rao

Final
(Closed Book & Closed Notes)

August 8 (Tuesday), 2006
6:00 P.M. – 7:50 P.M.
Show all your work.

Student Name: _____
Student ID: _____

1. [20 points]

A 512x512 input image (8 bit PCM) is decomposed into 7 unequal subbands as shown in fig.1. Assume that 8 bits are allocated to each sample in the first subband, 4 bits are allocated to each sample in subbands 2,3,4, and 2 bits are allocated to the rest. This decomposed image is sent through a 9600 bits-per-second channel in a progressive manner. Specifically, stage 1 of transmission contains information of subband 1 only, stage 2 contains information of subbands 2,3,4, and stage 3 contains information of subbands 5,6,7. How long would it take to transmit each stage of transmission and what fraction of image is sent during the same time by normal transmission (without subband coding).

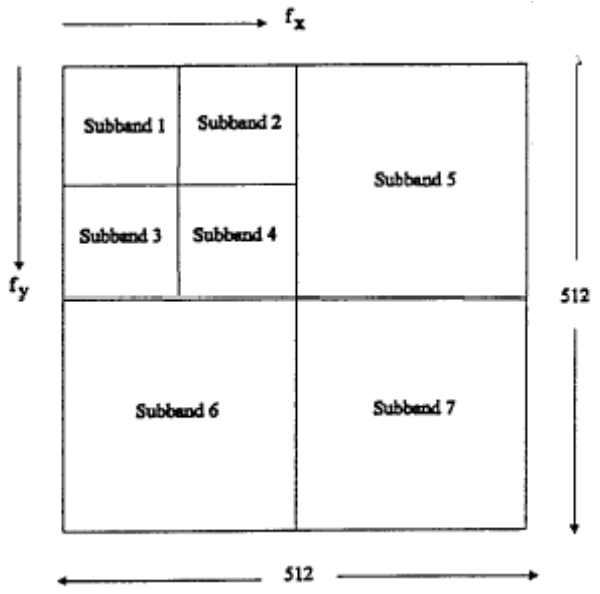

fig.1

2. [15 points]

a) Show in a block diagram format (using LPF, HPF, and decimators) how you can obtain the subband decomposition shown in fig.1.

b) Repeat a) to obtain the original (512x512) image, i.e., Subband synthesis (using also interpolators).

3. [10 points]

Given a symmetric LPF,

$h_n = h_{N-1-n}$, $n = 0, 1, \cdots, \frac{N}{2} - 1$, consider N=8, $\{h_n\} = \{h_0, h_1, h_2, h_3, h_4, h_5, h_6, h_7\}$

HPF is the QMF (Quadrature Mirror Filter). What are the coefficients of the HPF? Is this a linear phase filter?

4. [15 points]

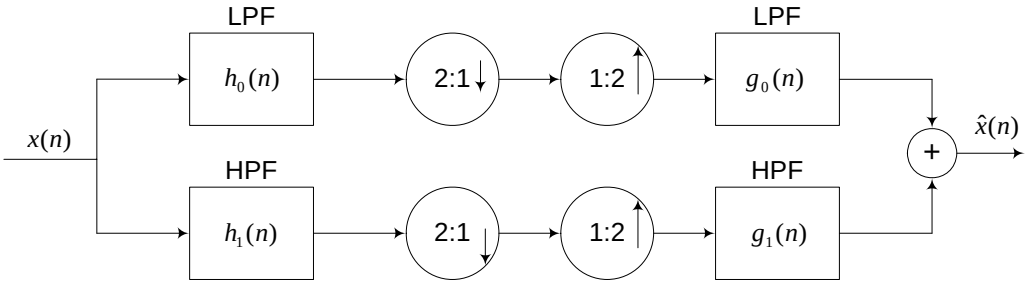

fig. Two channel filter banks

Given $h_0(n) = h_0(N-1-n)$, $n = 0, 1, \cdots, \frac{N}{2} - 1$. How are $h_1(n), g_0(n) \& g_1(n)$ related to $h_0(n)$ for the system to be PR ?

5. [15 points]

		NN	NNE
	NW	N	NE
WW	W	X	

fig. Labeling the neighbors of pixel X

Refinement to initial prediction $\hat{x}$ is as follows. Form the vector [N, W, NW, NE, NN, WW, 2N-NN, 2W-WW], Compare each component of it's vector with $\hat{x}$ and set each component to 1 if it is less than $\hat{x}$. Otherwise set to 0. Show that because of the dependence of the various components, there are only 144 possible configurations in this vector.

6. [25 points]

Given the (constraint) average bit rate $R = \frac{1}{M}\sum_{k=1}^{M} R_k$, where M= # of subbands, R_k = average # of bpp for subband k. Minimize the total reconstruction error $\sigma_r^2 = \alpha \sum_{k=1}^{M} 2^{-2R_k} \sigma_{yk}^2$, where σ_{yk}^2 is the reconstruction error variance for the kth subband, subject to the constraint, derive

$$R_k = R + \frac{1}{2}\log_2 \frac{\sigma_{yk}^2}{\left[\prod_{k=1}^{M}\left(\sigma_{yk}^2\right)\right]^{\frac{1}{M}}}$$

Hints:

Set up the minimization problem in terms of Lagrange multiplier as

$$J = \alpha \sum_{k=1}^{M} 2^{-2R_k} \sigma_{yk}^2 - \lambda\left(R - \frac{1}{M}\sum_{k=1}^{M} R_k\right)$$

$$d(a^u) = a^u (\log_e a) du$$

Make the derivation very clear. Show all the steps.