CARE, IIT Delhi

CRL702 Architectures and Algorithms for DSP Systems 2006-07/II

Major Exam

- **Maximum Marks: 60; Time Allowed: 2 hours.**
- **You can use the Instruction Set Summary of the TMS320C55xx DSP.**
- **Any assumptions made must be justified and clearly stated.**

1. Give three important features of the TMS320C5510 processor and show how they can be exploited by you as an assembly language programmer to provide a low energy solution for executing a given algorithm. (6 marks)

2. In an experiment involving two dice, one of them is thrown at a time and the outcome O_n at time n is observed. However, the particular dice thrown is hidden from the observer. The state transition probabilities for the two dice A and B are given by P(A/A) = 0.3, P(B/A) = 0.7, P(A/B) = 0.6, P(B/B) = 0.4. The probabilities of observations 1,…,6 given dice A is used are 0.2, 0.2, 0.2, 0.2, 0.1, 0.1 respectively and the probabilities of observations 1,…,6 given dice B is used are 0.1, 0.1, 0.3, 0.1, 0.2, 0.2 respectively. If the observed sequence of outcomes O_n is 6,1,2,5 for n = 1,2,3,4 respectively, and the choice of the dice at the start is equiprobable, use the Viterbi algorithm to obtain the most likely sequence of dice for the 4 outcomes. (10 marks)

3. Design a 2nd order optimal linear predictor for the sequence $x[n] = 1, 0, -1, 1, 2, 3, 2, -1,$ $n=0,1,\ldots,7,$ using the autocorrelation method. Assume a rectangular window in this case.
   i) Derive the coefficients using the normal equations.
   ii) Derive the coefficients using Levinson-Durbin recursion.
   iii) Obtain the minimum mean-squared error for the second order predictor.
   iv) What is the signal-to-noise ratio in decibels, where noise represents the prediction error sequence?

   (12 marks)

4. On your first day at job, your project manager asks you to design the minimum specifications of a DSP that will meet the following requirements for a hand-held, battery operated signal analyzer. A 4 MHz sampled signal has to be analyzed in real-time by taking 8-point FFT of successive 8 samples of the signal. The magnitude spectrum has to be averaged across the FFTs taken over each 1 second of the signal and displayed on the LCD panel as a graphical movie with a 1 second frame rate. The dynamic range of the signal is expected to be of the order of 50 dB and is constrained by the noise floor. A Li-ion battery pack (rating: 180 W-hr/kg) will be used. The device is expected to operate continuously without battery recharge for 12 hours, and the weight of the battery pack should not exceed 100 g because a competing company also claims to have the same weight. (This is how "intelligent" project managers think.)

   Being the only DSP engineer in the company does not intimidate you. You approach the task confidently upon recalling that in your M.Tech days, you had done a certain FFT experiment on the CCS, and that too all by yourself. We now return to the present.

Give all the minimum specifications that the DSP should satisfy to meet the above requirements. Show how you arrived at those specifications. (12 marks)

5. Write a program to find the quantization index *indx* of a given integer number v, such that the corresponding entry c_{indx} in the quantization table **C** is the nearest Euclidean distance neighbor of v. The program should implement the efficient tree based successive approximation outlined below.

   Let $\mathbf{C} = \{c_k,\ k = 0,1,\ldots,N-1\}$ be the quantization table with N entries (assume N is a power of 2). The algorithm finds the nearest neighbor index in $\log_2 N$ steps. Store the table of quantizer boundary values, $Y = \{y_k = (c_{k-1} + c_k)/2,\ k=1,\ldots,N-1\}$.

   (a) Initialize integer variables, *step* = *indx* = N/2.
   (b) Repeat i) and ii) below for $(\log_2 N) - 1$ times:
      (i) *step* = *step/2*
      (ii) if $(v > y_{indx})$, then *indx* = *indx* +*step;*
      else *indx* = *indx* – *step;*
      (iii) if $(v < y_{indx})$, then *indx* = *indx* -*1*;

   Implement the program for N = 16, and the quantization table:
   C = {-250, -200, -140, -80, -50, -30, -20, -10, 0, 20, 40, 70, 110, 150, 210, 240}.
   For $v = 60$, show how the variables change over the different iterations. What will be the quantized value of v? (14 marks)

6. Give the algorithm steps to add two floating point numbers in a DSP with fixed point twos complement arithmetic. Assume that the mantissa and exponent of the floating point numbers are stored in two data memory locations. (6 marks)