ECSE 436 **November 19, 2015**

Prof. Bajcsy **<u>MIDTERM EXAM</u>** **Time: 10:05-11:25**

Instructions: **1.** This is a CLOSED TEXTBOOK and OPEN CLASS NOTES examination.
2. Attempt all **4 problems.** Each part, e.g. (a), (b), (c), carries the same weight.
3. Derive/Prove each answer or give reference to a fact covered in class/textbook.
4. Only faculty calculators are allowed.
5. Write your answers on both sides of this exam paper.

Problem 1: Image Processing Elements

Assume you are given an grey scale intensity image *I(x,y)* that is 1000 by 1000 pixels in size and uses standard 8-bits per pixel representation (e.g., a larger image of Lena used in Lab 3).

(a) First explain how a digital camera works to capture and store such an image using charged coupled devices.

(b) Consequently, explain how a night vision camera (discussed in class) can make a low intensity image acquired at night to be visible on a display screen. Use your own words and system diagram to explain signal processing involved.

(c) Finally, you know that the face in the given image is located in a rectangular area for *x=600,601,...,800* and *y= 500, 501,…, 699, 700.* W<u>rite a short MATLAB script</u> which will make the person's face un-recognizable in this provided picture. Comment/explain how and why your Matlab script works. (**HINT:** Use either <u>sub-sampling</u> of the face region or excessive <u>quantization</u>.)

Problem 2: Signal Processing for Wireless Communication

(a) Consider a *(16, 5, 8)* binary linear Reed-Muller code used by NASA for transmission of data from their early Mars probes. Given its generator matrix

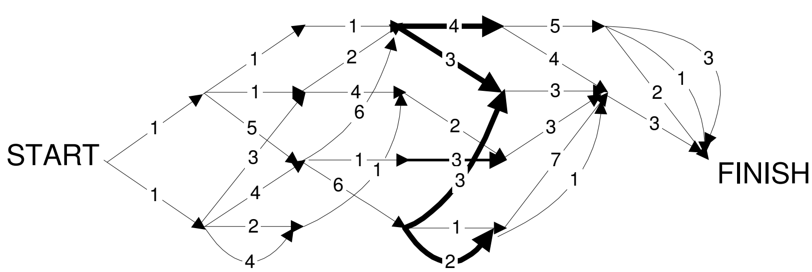
$$\mathbf{G} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{pmatrix}.$$

Decode all erasures in the following received codeword that contains erasures:

(1 1 1 E_1 E_2 1 0 E_3 E_4 E_5 E_6 0 0 1 1 E_7)

(<u>Hint:</u> Note the symmetry of the parity checks 1,2, …., 9 for this code.)

(b) Use the Viterbi algorithm to find first the <u>shortest</u> path and then also the <u>longest</u> path from *Start to Finish* in the decoding trellis below. (The edge labels correspond to distances in your decoding metric). Document each step of your <u>add-compare-store</u> process, i.e., your survivor paths, their 'growth' and elimination, etc.



Problem 3: Digital Signal Processing

Consider a discrete-time echo system that has an impulse response $h[0]= 0.5$, $h[1]= -1$ and $h[2]= 0.5$, while $h[n]=0$ for all other values of n.

(a) Sketch a finite shift register structure of this system and write down the input-output equation between input signal $x[n]$ and output signal $y[n]$.

(b) Describe a linear, time-invariant inverse system that recovers $x[n]$ from $y[n]$ (i.e., eliminates the echo) and sketch its block diagram.

(c) Determine if the systems in parts (a) and (b) are each causal and/or BIBO stable. Fully justify your reasoning.

Problem 4: FPGA Hardware for Signal Processing

Given the following structure AND assuming the design compiles, determine the output sequence when the input sequence is [00101100].

EXTRA CREDIT: Will this design actually compile? Why or Why not? State your reasoning.