

ECS 455: In-Class Exercise # 15

Instructions

1. Separate into groups of no more than three persons.
2. The group cannot be the same as any of your former groups in this class.
3. Only one submission is needed for each group.
4. **Write down all the steps** that you have done to obtain your answers. You may not get full credit even when your answer is correct without showing how you get your answer.
5. **Do not panic.**

Date: <u>05/05/2017</u>			
Name			ID (last 3 digits)
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A 64×64 Hadamard matrix is created in MATLAB via the command

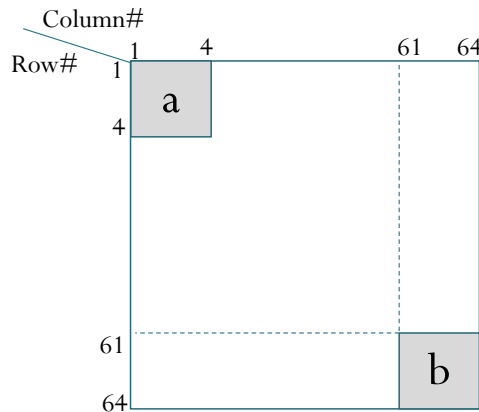
$$H = \text{hadamard}(64).$$

Note that the elements of H are all 1 or -1. Of course, there are 4,096 elements in H . Writing them all down would take too much time. So, in this question, you are asked to identify only parts a and b shown in the following picture:

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$H_4 = H_2 \otimes H_2 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$H_{64} = H_{16} \otimes H_4$$



$$H_{16} = H_4 \otimes H_4$$

$$\downarrow$$

$$H_{16}(1,1) = H_4(1,1) \times H_4(1,1)$$

$$= 1 \times 1 = 1$$

$$H_{16}(16,16) = H_4(4,4) \times H_4(4,4)$$

$$= 1 \times 1 = 1$$

Remark: The picture is not drawn to scale.

- a. Find $H(1:4, 1:4)$. (This is the part of H that is denoted by (a) in the picture above. It covers rows 1 to 4 and columns 1 to 4.)

$$[a] = \underbrace{H_{16}(1,1)}_1 \times H_4 = H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

- b. Find $H(61:64, 61:64)$.

$$[b] = \underbrace{H_{16}(16,16)}_1 \times H_4 = H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$