

CMPUT 414

Lab Exercise 1

Due Date: Jan. 16 23:55 PM

Read the Notes on Compression Posted with Lab by Jan 9, 2015

Your TAs will go over relevant parts of these notes in Lab

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1. [20] Consider an 10x10 image with six possible gray levels, 0,1,2,3,4,5 as shown below:

```
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1
1 1 1 1 1 1 1 1 2 2
2 2 2 2 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3
4 4 4 4 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5
```

For parts (a) to (c) assume binary coding (i.e., only 0 & 1 transmitted).

- (a) [4] Calculate probabilities of six gray levels.

$$0: 18/100 = 0.18$$

$$1: 10/100 = 0.1$$

$$2: 6/100 = 0.06$$

$$3: 36/100 = 0.36$$

$$4: 4/100 = 0.04$$

$$5: 26/100 = 0.26$$

- (b) [4] Calculate the entropy.

$$i = 6,$$

$$p_0=0.18, p_1=0.1, p_2=0.06, p_3=0.36, p_4=0.04, p_5=0.26$$

$$H = \sum_{i=0}^5 p_i \times \log_2 \left(\frac{1}{p_i} \right)$$

$$H = 2.243$$

- (c) [12] Apply reduction process to construct a compact variable-length Huffman code, illustrates the codeword construction process, and calculate code efficiency with respect to entropy.

Symbol	Probabilities	Reduction 1	Reduction 2	Reduction 3	Reduction 4
3	0.36	0.36	0.36	0.36	0.62
5	0.26	0.26	0.26	0.26	0.38
0	0.18	0.18	0.18	0.38	
1	0.1	0.1	0.2		
2	0.06	0.1			
4	0.04				

Symbol	Code Step 5	Code Step 4	Code Step 3	Code Step 2	Code Step 1
3	11	11	11	11	1
5	10	10	10	10	
0	00	00	00	0	0
1	010	010	01		
2	0111	011			
4	0110				

Efficiency Calculation:

$$\begin{aligned}
 E &= H / \sum (p_i \times \text{length}_i) \\
 &= 2.243 / 2.3 = 97.5217\%
 \end{aligned}$$

2. [10] Consider a 24-bit 1024 x 1024 resolution (R, G, B) image to be compressed by JPEG baseline standard. If the (R, G, B) image is transformed to (Y, Cb, Cr), and the chrominance components are reduced to 256 x 256 resolution each, what would be the size of the compressed JPEG color image relative to a JPEG compressed 8-bit 1024 x 1024 greyscale image?

(Assume that the compression efficiency is same for all 8 x 8 blocks for greyscale or color images.)

Y: 1024 x 1024

Cr and Cb are both 256 x 256

Therefore, the size is

$$(1024^2 + 256^2 + 256^2) / (1024^2) = 1.125$$

times greater than the compressed JPEG of size 1024 x 1024, where both images are 8-bit.