EQ2330 – Image and Video Processing

Solution #7

Solution

1. Four shades of gray are represented by two bits. Hence, $512 \times 512 \times 2 = 524288$ bits are needed.

2. The entropy is given by

$$H(j) = -\sum_{j=0}^{3} p(j) \log_2 p(j) \approx 1.5799 \text{bits}.$$

3. The lower bound on the bits needed per pixel is given by the entropy of the image. The entropy is maximized when the histogram is flat. However, this is not the whole truth. Inter-pixel correlation can be used to perform better than the per-pixel entropy bound. Hence, an image with a flat histogram and statistically independent pixel values are the most difficult to encode.

4. The following Huffman code gives an average codeword length of 1.6630 bits, which, as expected, is larger than the entropy.

gray level j	codeword	codeword length $\ell(j)$
0	110	3
1	10	2
2	0	1
3	111	3

5. $\sum_{j=0}^{3} 2^{-\ell(j)}$ evaluates to 1.