

PROBLEM SET
SYMBOL CODES
(MACKAY - CHAPTER 5)

Necessary reading for this assignment:

- *Information Theory, Inference, and Learning Algorithms* (MacKay):
 - Chapter 5.1: *Symbol codes*
 - Chapter 5.2: *What limit is imposed by unique decodeability?*
 - Chapter 5.3: *What's the most compression we can hope for?*
 - Chapter 5.4: *How much can we compress?*
 - Chapter 5.5: *Optimal source coding with symbol codes: Huffman coding*
 - Chapter 5.6: *Disadvantages of the Huffman code*
 - Chapter 5.7: *Summary*

Note: The exercises are labeled according to their level of difficulty: [Easy], [Medium] or [Hard]. This labeling, however, is subjective: different people may disagree on the perceived level of difficulty of any given exercise. Don't be discouraged when facing a hard exercise, you may find a solution that is simpler than the one the instructor had in mind!

Review questions.

1. Answer formally the following questions:
 - (a) What is a symbol code for an ensemble? What is an extended code for an ensemble?
 - (b) When is a symbol code uniquely decodable? When is a symbol code prefix-free?
 - (c) State Kraft's inequality and explain in what sense it is related to the notion of which prefix-free codes are actually possible.
 - (d) Explain what the Source coding theorem for symbol codes means in terms of the limits of compression of an ensemble.

Exercises.

2. (MacKay 5.19) [Easy]
3. (MacKay 5.20) [Easy]
4. (MacKay 5.21) [Medium] You only need to do:
 - (a) X^2 and X^3 when $\mathcal{P}_X = \{0.9, 0.1\}$; and
 - (b) X^2 when $\mathcal{P}_X = \{0.6, 0.4\}$.
5. (MacKay 5.22) [Medium]
6. (MacKay 5.24) [Easy]