

CS294-082: Experimental Design for Machine Learning on Multimedia Data  
Fall 2020

Homework 3

Entropy:

- 1) How much information in bits is represented by a clock with hour and minute hand?
- 2) You have a compass.
  - a) Assume you implement a binary classifier based on the direction of the compass needle (e.g., “north-facing enough?”). What is the maximum amount of information in bits that this compass classifier can represent?
  - b) How could you modify your compass classifier to represent less information?
  - c) Instead of a binary classifier, you implement a general classifier. What is the maximum amount of information in bits you can train your compass to represent as a function of the number of thresholds?

Neurons:

- 3) Show that the maximum output of a threshold neuron is maximally one bit, independent of the activation function. Hint: Do exercise 2 first.
- 4) Boolean functions.
  - a) Draw the decision tree for the NAND function of two boolean inputs.
  - b) Draw an artificial neuron that implements NAND for two boolean inputs.
  - c) Draw a three-neuron artificial neural network that implements equality for two boolean inputs.
  - d) Draw a two-neuron artificial neural network that implements equality for two boolean inputs.
  - e) How do you have to change b) for non-boolean inputs?
- 5) Show by induction that  $T(2n,n)=0.5T(n,n)$ . (The  $T(n,k)$  function is defined in MacKay’s book, Chapter 40).
- 6) Describe a process to black-box benchmark practical implementations of neural networks based on the  $T(n,k)$  function.