ECE 2066: Science of Information

Spring 2018

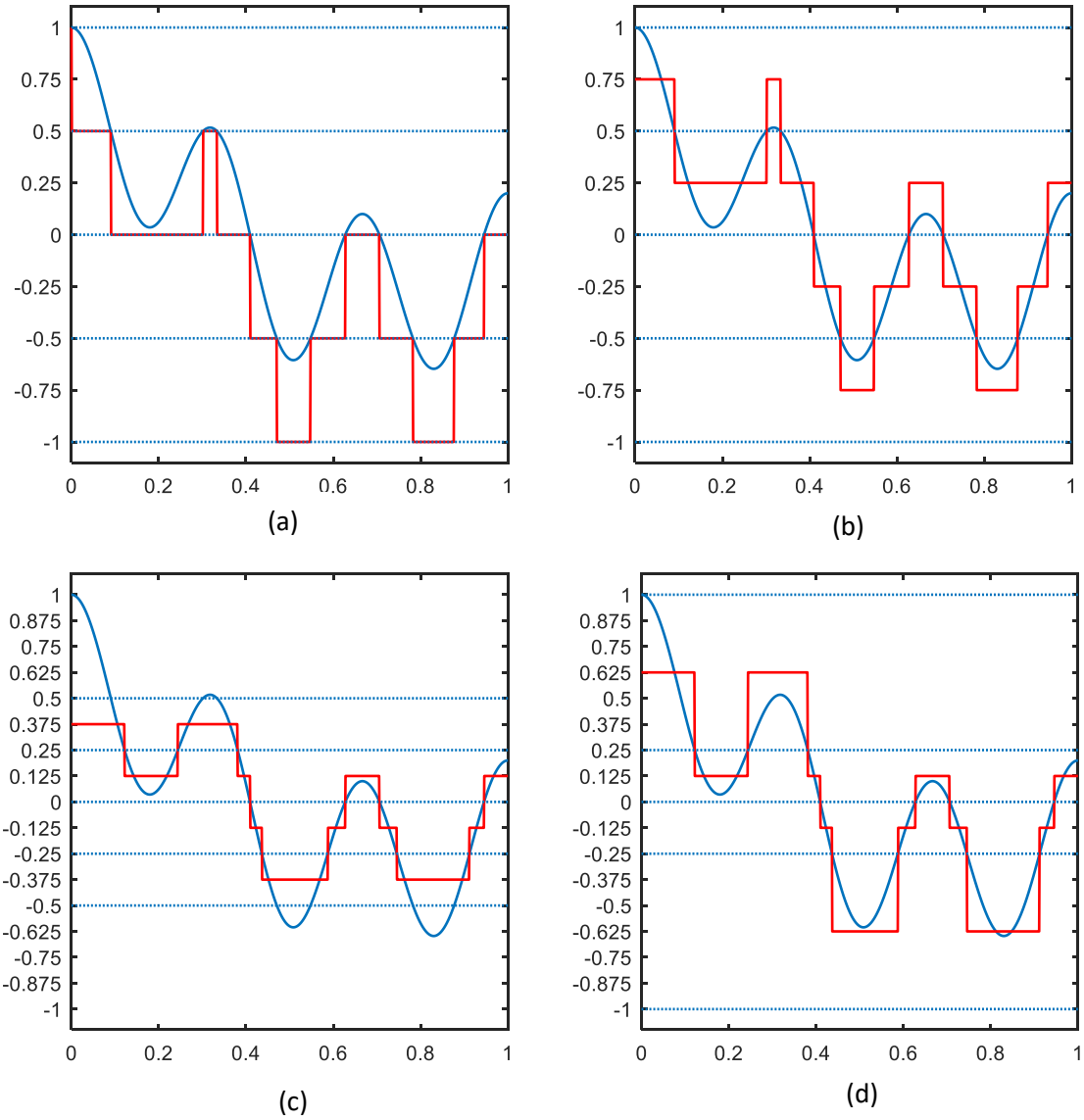
Homework 2

Instructions: This homework assignment is subdivided into two parts. Each part must be turned in on a separate sheet (or sheets) of paper. Please put both your name and computing ID (e.g., ffh8x) on each part. You must show your work to receive full credit for a problem. Each problem will be graded on a scale of 0-2. Please turn in legible and complete answers. While you are encouraged to discuss your approach with your classmates, all your answers must be your own.

Part 1: Analog and Digital Signals

1. Each of the following components found in an iPhone is responsible for measuring a real-world signal which is then digitized: (a) Microphone, and (b) Camera (when taking pictures).
   I. For each component, consider the real-world signal being measured, and describe what physical quantities are reflected in the domain (index) and range (value) of that signal.
   II. Check out this webpage on Apple's developer guide and answer the following questions. The guide suggests example high and low values for audio sample rate. What are they? For recording 5 min of stereo audio at quantization bit depth of 16 bits/sample, what are the file sizes (in Bytes, each Byte=8bits), for high and low sampling rates? The components do not transmit each sample as they become available, but rather they are buffered and sent in batches. The guide gives typical buffer durations for high and low quality audio. How many sample will the buffer contain for stereo audio at high sampling rate? How large (in Bytes) does the buffer have to be at 16 bits/sample?

2. The plots below show a signal (blue) quantized in four different ways (red). The domain of the signal is from 0 to 1 and its range is from -1 to 1. For each case:
   I. Determine what range of signal values are mapped to what quantized value.
   II. What is the binary representation for the (quantized) value of the signal at time 1? Assume that the lowest quantized value is mapped to 00 and the second lowest is mapped to 01 and so on.
   III. What is the maximum possible quantization error (defined as the difference between an actual value and the quantized value it is mapped to)?

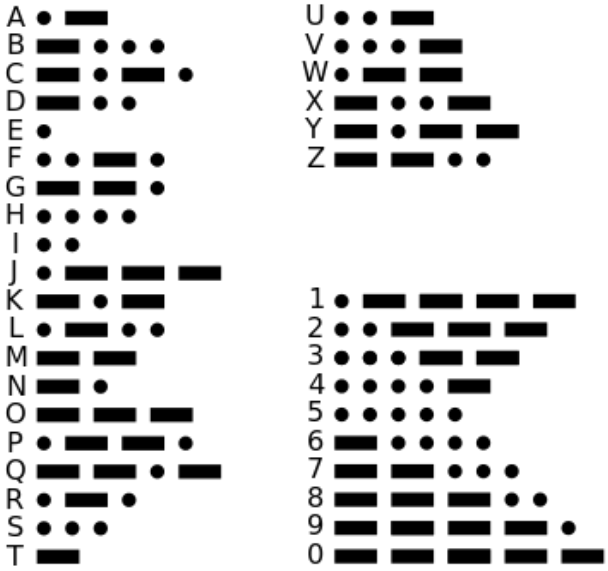


Part 2: Signal Representation

3. Perform the following computations in 6-bit two's-complement system. Convert your binary result back into decimal.
   I. 12 + 17
   II. 12 - 17
   III. 12 + 21. Why is the decimal representation of the binary answer not 33?

4. Morse code is a simple example of a variable-length code, where the number of dashes and dots needed to represent a letter roughly depends on how frequently that letter is used. For instance, common letters like "E" or "T" are one symbol, while rare letters like "X" have four symbols. A chart

listing the dashes and dots for letters and numbers is shown below:



How many dashes and dots are needed to encode the sentence "TO BE, OR NOT TO BE.", ignoring spaces, periods, and commas? Suppose we instead use the shortest fixed-length binary code that can encode 26 symbols. How many bits would be needed to encode the same sentence? Later in the semester, we will study fixed and variable-length codes in more detail.

Due by hard copy in class (Wednesday at 2 pm).