ELEX 3525 : Data Communications
2019 Fall Term

Assignment 1

Due Friday, October 18, 2019. Submit your assignment using the appropriate Assignment folder on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero. **Show how you obtained your answers.**

Question 1

(a) An image communication system transmits pixels that can take on 64 different values. Half of the pixels transmitted have the same value (0). The other pixels have values between 1 and 63 and all of these values have the same probability. What is the entropy of this source in bits/pixel?

(b) What is the information rate in bps if a 1920×1020 image is scanned every 16 ms and has the above pixel value distribution?

Question 2

A communication system transmits data in the form of frames (packets). Each transmitted frame is acknowledged by a second frame received on the same channel. The transmitted frame has 1150 bytes of data and 100 bytes of overhead (header and parity) which are not delivered to the user. The acknowledgement packet is 50 bytes long and carries no user data. Both types of frame are transmitted at a rate of 1 Gb/s.

(a) What is the throughput of this system assuming no gaps between frames.

(b) Now assume there is a delay between each frame that corresponds to twice the free-space propagation delay over a distance of 300 m. What is the throughput in this case?

Question 3

(a) Use a web site such as `https://translate.google.com` to find the (simplified) Chinese character for your favourite color (when used as an adjective). Pick a simple color that has a one-character translation. What is this character (paste or write the character in your answer).

(b) Use the lookup tool at `https://www.unicode.org/cgi-bin/GetUnihanData.pl` or other source to get the Unicode code point. Give your answer in 'U+' format.

(c) Show how the UTF-8 encoding is derived from the code point value (show your work).

Question 4

Flip a coin 60 times and mark down a 1 for heads and 0 for tails.

(a) Compute the histogram for a random variable whose values are the 0 and 1 values you generated above.

(b) Compute a new random variable that is the sum of every five successive flips. This random variable will have values between 0 and 5. Compute the histogram for this new random variable.

(c) What probability density function would you expect to see if you used a very large number of coin flips and summed a large number of 0/1 values (instead of just 5)?

Hint: You can use a random number generator instead to create the random numbers. For example, in octave (or Matlab) the expression `x=rand(60,1)>0.5` *will create 60 random 0/1 values and the expression* `y=reshape(x,5,12)` *will rearrange the values into 12 columns of 5 values each. The expreswion* `sum(y)` *will add up the columns. The expression* `hist(sum(y))` *will plot a histogram. If you use octave, try increasing the number of columns (e.g. to 1000) and rows (e.g. to 12) to see the effect.*

Question 5

A sound system claims to use 24-bit quantization and a sampling rate of 192 kHz.

(a) Approximately what quantization SNR could be achieved with this many bits?

(b) If the signal voltage was 1 Vrms, what would be the rms noise voltage?

(c) What range of frequencies can be reconstructed with this sampling rate?

(d) Compare this to the typical range of frequencies that a newborn baby can hear.

Question 6

A communication system uses pulses of four different durations (1, 2, 3 and 4 ms). Each pulse is separated by a 1 ms gap. Each pulse duration is equally likely.

What are:

(a) the number of bits transmitted with each pulse?

(b) the average symbol rate?

(c) the average data rate in bps?

(d) the average information rate?

(e) the baud rate, assuming it's defined as the reciprocal of the minimum time between level transitions?

Show your work and specify the units.