ENGS252 Signals and Systems - Homework 1

Mher Saribekyan A09210183

February 9, 2026

Problem 1

Consider a digital mp3 player that has 1024×10^6 bytes of memory. Assume that the audio clips stored in the player have an average duration of five minutes.

a) Assuming a sampling rate of 44100 samples/s and 16 bits/sample/channel quantization, determine the average storage space required (without any form of compression) to store a stereo (i.e. two-channel) audio clip.

$$5 \cdot 60 \cdot 44100 \cdot 16 \cdot 2 = 423.36 \text{Mb} = 52.92 \text{MB}$$

b) Assume that the audio clips are stored in the mp3 format, which reduces the audio file size to roughly one-eighth of its original size. Calculate the storage space required to store an mp3-compressed audio clip.

$$\frac{423.36}{8} \text{Mb} = 52.92 \text{Mb} = 6.615 \text{MB}$$

c) How many mp3-compressed audio files can be stored in the mp3 player?

$$\frac{1024 \times 10^6}{6.615 \times 10^6} \approx 154 \text{ songs}$$

Problem 2

Consider a digital color camera with a resolution of 2560×1920 pixels.

a) Calculate the storage space required to store an image in the camera without any compression. Assume three color channels and quantization of 8 bit/pixel/channel.

$$2560 \cdot 1920 \cdot 8 \cdot 3 \approx 117.96 \text{Mb} = 14.745 \text{MB}$$

b) Assume that the images are stored in the camera in the JPEG format, which reduces an image to roughly one-tenth of its original size. Calculate the storage space required to store a JPEG-compressed image.

$$\frac{117.96}{10} \text{Mb} \approx 11.80 \text{Mb} = 1.47 \text{MB}$$

c) If the camera has 512×10^6 bytes of memory, determine the number of JPEG-compressed images that can be stored in the camera.

$$\frac{512 \times 10^6}{1.47 \times 10^6} \approx 348 \text{ images}$$

Problem 3

Consider a signal those amplitudes can be changed from $0V$ up to $30V$. Your quantizing system has 4 bit resolution. The quantization is uniform.

a) What is the number of quantization levels?

$$2^4 = 16 \text{ levels}$$

b) What are the decision/reconstruction levels of quantization?

Mid-rise was selected.
$$\Delta = \frac{30 - 0}{16} = 1.875V$$

Decision levels are $n \cdot 1.875$, for $n \in \{0, 1, 2...15\}$ or equivalently $\{0, 1.875, 3.75, ..., 28.125\}$
Reconstruction levels are $0.9375 + n \cdot 1.875$, for $n \in \{0, 1, 2...15\}$, which are the mid points for the intervals or equivalently $\{0.9375, 2.8125,...,29.0625\}$.

c) What is the amplitude resolution of your system?

Same as the step size, $1.875V$. Voltage changes smaller than the step size cannot be measured accurately.