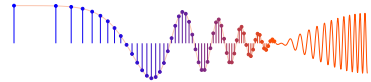


PROBLEM:

In Lab #4 you synthesized some music. In this problem we will explore the way that the same information can have different forms if we manipulate the information with digital computation.

(a) Obtain the sheet music for *Jesu Joy of Man's Desiring* in a pdf file. Determine its size. Record the number of bytes of storage required for this representation of the music.

(b) Download the lab archive with the data files in it. Load `jesu_joy.mat` into MATLAB and check to see the total size of the data structure that is loaded in. Record this number.

(c) **Optional for Musicians:** The numerical representation in `jesu_joy.mat` is *almost* an exact representation of the information on the sheet music. What information is missing in `jesu_joy.mat`?

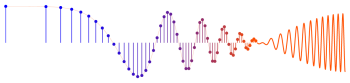
(d) Assume that you set the tempo at `bpm=200` beats per minute and you synthesized the tones prescribed by `jesu_joy.mat` to produce a vector of samples of synthetic music. Assume that you used a sampling rate of $f_s = 11025$ Hz. The resulting samples are computed with the full 64 bit (8 byte) precision of MATLAB. How many bytes of storage will the resulting vector consume in MATLAB?

(e) Now when the synthesis vector is sent to the D-to-A converter, the samples are "quantized" to 16 bits (2 bytes) per sample. How many bytes of information are sent to the D-to-A converter?

You should have found that the music in its different forms requires different amounts of digital storage. Do you think that the smallest value determined above is the absolute minimum that could be used to represent this sequence of tones?

McClellan, Schafer and Yoder, *Signal Processing First*, ISBN 0-13-065562-7.
Prentice Hall, Upper Saddle River, NJ 07458.

SOLUTION



Part A

Sheet music file (jesu_joy.pdf) requires 14992 bytes of storage.

Part B

MATLAB data structure (theVoices) loaded from jesu_joy.mat requires 9856 bytes of storage.

Part C

A few subtle pieces of information missing from the numerical representation, but contained in the sheet music representation, include the volume descriptors (such as the "piano" and "mezzoforte" symbols and the crescendo and diminuendo markings) as well as the "musical phrasing" descriptors (such as the legato lines and the marcato symbols).

Part D

- (17 measures of music)*(3 beats per measure) =**51 beats**
- (51 beats)/(200 beats per minute)*(60 seconds per minute) =**15.3 seconds**
- (15.3 seconds of music)*(11025 samples per second) =**168683 samples** (rounded up)
- (168683 samples)*(8 bytes of storage per sample) =**1349464 bytes** of total storage

Part E

(168683 samples)*(2 bytes of storage per quantized sample) =**337366 bytes** of quantized information