COE 301 Introduction to Computer Programming Fall, 2019

Homework 10 – Due: 11/22/2019 9:00 am

Problem 1. (25 points)

(1) [6 points] Given that

```
A = [1 3;2 4]
B = [3 0;0 1]
```

What is the output of the following expressions?

```
a)   A * B
b)   A .* B
c)    max(A)
```

(2) [6 points] Given that

```
A = [1  2  3  4; 5  6  7  8; 9  10  11  12]
```

What is the output of the following expressions?

```
a) A(2, end)
b) A(4)
c) A(:,1:2:end)
```

(3) [6 points] Please write MATLAB command(s) to create the following vectors and matrices **without loops**:

a) A 1000-by-500 matrix of ones.
b) A row vector with integers from 1 to 1000 as [1 2 3 …. 999 1000].
c) A 5000-by-5000 square identity matrix with ones on the main diagonal and zeros elsewhere.

(4) [2 points] If A is a 4-by 2 matrix and B is a 5-by-2 matrix, which one is a valid MATLAB operation? `A*B` or `A*B'`?

(5) [5 points] what is the output of the following block of MATLAB code?

```
n = 4;
D = diag(ones(n,1))+diag(-1*ones(n-1,1),1);
D(end,:) = [];
x = [1; 3; 6; -9];
disp(D*x)
```

Problem 2. (25 points) There are x chickens and y rabbits in a cage. There are 72 heads and 200 feet inside of the cage. How many chickens are there and how many rabbits are there in the cage?
Write the problem as a system of two equations and solve x and y by hand. Now write a MATLAB script to solve x and y and compare your results.

Report your derivation (by hand) and the MATLAB code output in the write-up.
Please submit your .m file as "yourLastName_hw10_prob2.m" with all the MATLAB commands you used.

Problem 3. [25 points] The Central Limit Theorem states that the sums of sets of N random variables will tend toward having a normal distribution as N increases.
In this problem, we will test this theorem using a MATLAB script as follows: create N = 2 random vectors and each vector with L=10^6 samples that are uniformly distributed between [-0.5 and 0.5], Plot the histogram with 40 bins of the sum of these two vectors. Now repeat for the case for N = 3 and 6 and plot the corresponding histograms. What do you see?
Note: We can use the "histogram" to show the general frequency of the numbers in a vector v as: `histogram(b);`

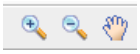
Report your figures and your observations in the write-up.
Please submit your .m file as "yourLastName_hw10_prob3.m" with all the MATLAB commands you used.

Problem 4. [25 points] MATLAB is a powerful tool for engineers. In this problem, we will show you how to manipulate music data using MATLAB. Let's first read in an audio file 'testaudio.wav' under the folder 'Lab10_data' and put the data in a vector x. The sampling rate (44 kHz) is in the variable Fs.

```
[x, Fs] = audioread('testaudio.wav');
```

(1) Plot a subset of the data

```
plot(x(100000:200000))
```

You may zoom in and drag the figure using the icon  above the figure. Find an interesting portion, save it and submit the result in the write-up.

(2) Looking at audio data in this way is not very useful. A common type of plot used by audio engineers is a spectrogram. This is a 2D plot with time on the x axis and frequency on the y axis. Bass sounds are near 0 and high-pitched sounds are near the top. Time progresses from left to right. Plot the spectrogram of the audio and submit it in the write up.

```
specgram(x, 1024, Fs);
```

Zoom in on the section from 10.6 to 11.6 seconds in time and 6000 Hz to 7000 Hz in frequency. Describe qualitatively and (as best as you can) quantitatively what you see. What caused this? What would this sound like if you could isolate only this portion and play it?

(3) Play the audio and describe what you hear. ***This audio has been corrupted by very annoying noise so you will want to turn the volume down and use headphones to avoid disturbing others.***

```
sound(x, Fs);
```

In audio processing, *digital filters* are used extensively to manipulate the sound of audio recordings. We will use one very basic filter called a *notch filter* here to try to eliminate the annoying sound:

```
% Filter coeffients
b = [ 0.999643720498015  -1.918666629446868 0.999643720498015 ];
a = [ 1.000000000000000  -1.918666629446868 0.999287440996029 ];
y = filter(b, a, x);
sound(y,Fs);
```

Describe how the sound has changed. Plot the spectrogram of y in the same way as before and compare. Notice that a small portion of the noise is still present at the beginning of the recording. How long does it persist (in seconds) before it becomes unnoticeable?

Extra credit [+10 points]: There is a special coded text message embedded in this audio recording. Find it and report it. Describe your work.

Report your figures and your explanations in the write-up.
Please submit your .m file as "yourLastName_hw10_prob4.m" with all the MATLAB commands you used.

Submission Instructions:

There should be 3 files in your submission:

1. A write up (any type- .txt, .docx, .pdf are all fine) that contains your answers to all questions in problem 1-4.

2. The .m file for problem 2.
3. The .m file for problem 3.
4. The .m file for problem 4.

Please make sure your last name is included in the filename.